PATENT ABSTRACTS OF JAPAN

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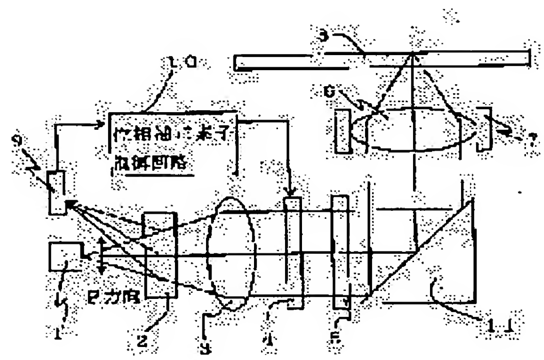
(54) OPTICAL HEAD DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To have an optical head device which can efficiently correct the spherical aberration originated in the optical disk thickness error and in which a good signal light with little noise is obtained.
SOLUTION: A liquid crystal layer which is sandwiched between a pair of substrates having electrodes on the surfaces is provided. The electrode of one substrate is provided with three concentric ring low-resistance electrodes and a high-resistance electrode which is disposed between the adjoining low- resistance electrodes and in which the ratio of the value of the sheet resistance thereof to that of the low-resistance electrodes is equal to or more than 1000, and the electrode of the other substrate is provided with a divided electrode consisting of a plurality of segment electrodes in which a planar electrode is segmented into concentric shapes. Further, a phase correction element 4 is obtained, in which the optical axes passing through respective centers of the low-resistance electrodes and the divided electrode agree with each other, and the element is installed in an optical path between a light source 1 of the optical head device and an objective lens 6.



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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The light source and the objective lens for making the outgoing radiation light from the light source condense on an optical recording medium, The phase correction component to which the wave front of the outgoing radiation light prepared between the light source and an objective lens is changed, It is optical head equipment equipped with a control voltage generating means to output the electrical potential difference for changing a wave front to a phase correction component. The phase correction component is equipped with the liquid crystal layer in which the electrode was pinched by the transparence substrate of the pair currently formed in the front face. The electrode of one transparence substrate Connect conductively the adjoining low resistance electrode which is arranged on low resistance inter-electrode at least, and adjoins to the low resistance electrode of the three or more shape of a circular ring allotted in the shape of a concentric circle. It has the high resistance electrode whose ratio of sheet resistance to a low resistance electrode is 1000 or more. The electrode of the transparence substrate of another side Optical head equipment characterized by having the division electrode which consists of two or more segment electrodes with which the flat electrode was divided in the shape of a concentric circle, and the core of a low resistance electrode and the core of a division electrode being on an optical axis.
[Claim 2] Optical head equipment according to claim 1 constituted so that a different electrical potential difference between the electrode of the transparence substrate which said two or more segment electrodes are divided into two segment electrode groups, are connected conductively for every segment electrode group, and counters, and each segment electrode group can be impressed.
[Claim 3] Said low resistance electrode is optical head equipment according to claim 1 or 2 it consists of an outside, middle, and three inside low resistance electrodes, and the ratio of the average of the inradius of a middle low resistance electrode and circumradius to the pupil radius of said objective lens is from 0.7 to 0.85, and the ratio of the difference of said inradius to the pupil radius of said objective lens and said circumradius is [equipment] from 0.02 to 0.14.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Especially this invention relates to the optical head equipment which performs record and playback of the information on optical recording media, such as an optical disk, about optical head equipment.
[0002]
[Description of the Prior Art] In order to raise the recording density of an optical disk in recent years, wavelength of the outgoing radiation light from the semiconductor laser which is the light source is shortened, or enlarging numerical aperture (NA) of an objective lens is put in practical use. It is setting wavelength of the light source to about 405nm, and setting NA to 0.85 in next-generation optical recording, and obtaining bigger recording density is proposed. However, the permissible dose of thickness fluctuation of short-wavelength-izing of the light source and a raise in NA of an objective lens of an optical disk by the cause becomes small.
[0003] Since the spherical aberration proportional to thickness fluctuation of an optical disk occurs, the cause by which these permissible doses become small is because the condensing property of optical head equipment deteriorates and reading of a signal becomes difficult. Moreover, in the case of the multilayer recording method which uses as a record layer the layer from which an optical disk differs, respectively, since the spherical aberration based on class spacing occurs, a means to amend spherical aberration is required.
[0004] The following methods are proposed as a means to amend spherical aberration. One has the method (mechanical control) which negates the spherical aberration which the location of a collimate lens is mechanically changed according to the amount of the generated spherical aberration, is made to generate spherical aberration between objective lenses, and is generated with the thickness error of an optical disk. In the case of this mechanical control, since a part for the mechanical moving part of a collimate lens is needed, there is a fault to which the configuration of optical head equipment becomes intricately or large.
[0005] There is a method (electric system) which amends wave aberration by impressing an electrical potential difference to the phase correction component which it had into the optical path between an objective lens and the light source as another method. In the case of this electric system, since the amount of machine moving part is not compared with a mechanical control, it excels in dependability, such as formation of small lightweight, and vibration. There is JP,10-20263,A as an example which amends wave aberration using a phase correction component. As a method which amends the comatic aberration generated with the inclination of an optical disk in this example, orientation was controlled by changing the electrical potential difference which impresses the liquid crystal pinched between the substrates of the pair which constitutes the phase correction component to a division electrode, and the comatic aberration which the wave front of the transmitted light is changed and is generated is amended.
[0006]
[Problem(s) to be Solved by the Invention] However, in the case of the conventional phase correction component, if its attention is paid to one division electrode, since the variation of the wave front of the transmitted light is the same, it will depend for the wave-front configuration

acquired on the number of signals impressed to the number of partitions (the number of division electrodes) of an electrode, and a division electrode. Therefore, in order to amend the wave aberration which changes continuously with a sufficient precision, it is necessary to increase the number of division electrodes and to control by many sources of an external signal (external power), and problems, such as complication of a component configuration and an external power configuration, arise. Then, a phase correction component to which it has simple electrode structure and the wave front of the transmitted light is continuously changed by few external powers was desired. The variation of wave aberration like the periphery of spherical aberration was wanted to amend a large field by continuous wave-front change especially.

[0007]

[Means for Solving the Problem] It is made in order that this invention may solve the above-mentioned technical problem. The light source, The objective lens for making the outgoing radiation light from the light source condense on an optical recording medium, The phase correction component to which the wave front of the outgoing radiation light prepared between the light source and an objective lens is changed, It is optical head equipment equipped with a control voltage generating means to output the electrical potential difference for changing a wave front to a phase correction component. The phase correction component is equipped with the liquid crystal layer in which the electrode was pinched by the transparence substrate of the pair currently formed in the front face. The electrode of one transparence substrate Connect conductively the adjoining low resistance electrode which is arranged on low resistance inter-electrode at least, and adjoins to the low resistance electrode of the three or more shape of a circular ring allotted in the shape of a concentric circle. It has the high resistance electrode whose ratio of sheet resistance to a low resistance electrode is 1000 or more. The electrode of the transparence substrate of another side The optical head equipment characterized by having the division electrode which consists of two or more segment electrodes with which the flat electrode was divided in the shape of a concentric circle, and the core of a low resistance electrode and the core of a division electrode being on an optical axis is offered.

[0008]

[Embodiment of the Invention] Drawing 1 is the conceptual diagram showing an example of the principle configuration of the optical head equipment of this invention, and performs the record and playback of the information on an optical disk which are an optical recording medium. It becomes parallel light with a collimate lens 3, the quadrant wavelength plate 5 is penetrated after penetrating the phase correction component 4, it is reflected in the direction of 90 degree by the starting mirror 11, and the outgoing radiation light from the semiconductor laser 1 which is the light source is condensed on an optical disk 8 with the objective lens 6 installed in the actuator 7, after penetrating the hologram type polarization beam splitter 2.

[0009] After it is reflected by the optical disk 8 and the condensed light penetrates an objective lens 6, the starting mirror 11, the quadrant wavelength plate 5, the phase correction component 4, and a collimate lens 3 contrary to previously one by one, it is diffracted by the polarization beam splitter 2 and carries out incidence to a photodetector 9. In case the outgoing radiation light from the above-mentioned semiconductor laser 1 is reflected by the optical disk 8, amplitude modulation of the reflected light is carried out by the information recorded on the field of an optical disk 8, and recording information can be read as a signal on the strength [optical] with a photodetector 9. Moreover, when recording information on an optical disk 8, the laser output of semiconductor laser 1 is modulated and information is recorded on the record film of an optical disk 8.

[0010] An electrical potential difference is outputted towards the phase correction component 4 by the phase correction component control circuit 10 which is a control voltage generating means so that the optical disk 8 obtained from a photodetector 9, for example, the reinforcement of a regenerative signal, may become the optimal. The electrical potential difference outputted from the phase correction component control circuit 10 turns into an electrical potential difference impressed to the electrode of the phase correction component 4 according to the spherical aberration generated from gaps, multilayer optical disks, etc. of optical system, such as a thickness error, an objective lens, etc. of an optical disk.

[0011] Next, the configuration of the phase correction component used in this invention is explained using the sectional view of drawing 2 . Glass substrates 21a and 21b paste up epoxy system resin by the sealant 22 used as a principal component, and the liquid crystal cell is formed. Although acrylic resin, epoxy system resin, vinyl chloride system resin, a polycarbonate, etc. are mentioned as ingredients other than glass with the substrate to be used, points, such as endurance, to a glass substrate is desirable.
[0012] The conductive spacer which carried out the coat of the gold etc. to the glass spacer and the front face of resin is contained in the sealant 22. The coat of the insulator layer 25 which uses electrode 24a, a silica, etc. as a principal component from an inside front face in the inside front face of glass substrate 21a, the insulator layer 25 to which the orientation film 26 uses electrode 24b, a silica, etc. as a principal component from an inside front face in the inside front face of glass substrate 21b again at this order, and the orientation film 26 is carried out to this order. It is an insulator layer 25 and it may exclude for preventing the inter-electrode short-circuit by the conductive foreign matter. Moreover, the coat of the antireflection film may be carried out to the outside front face of glass substrates 21a and 21b.
[0013] Pattern wiring is given so that electrode 24a can be connected with a phase correction component control circuit by the path cord in the electrode drawer section 27. Moreover, electrode 24b has connected above-mentioned gold etc. with electrode 24a formed on glass substrate 21a by the conductive spacer which carried out the coat electrically, therefore electrode 24b is connectable with a phase correction component control circuit in the electrode drawer section 27 with a path cord.
[0014] The interior of a liquid crystal cell is filled up with liquid crystal 23. The ingredient of the liquid crystal to be used has the good pneumatic liquid crystal used for a liquid crystal display etc., and in order for polarization not to change with applied voltage, its uniform homogeneous orientation is desirable. The liquid crystal molecule 28 shown in drawing 2 is in the condition of the homogeneous orientation by which orientation was carried out to the one direction.
[0015] Moreover, as an ingredient of the orientation film, if the pre tilt angle of the liquid crystal molecule 28 becomes 2-10 degrees, it is desirable, and what was parallel to the space of drawing 2 and carried out rubbing of the polyimide film to the longitudinal direction, the thing which carried out the slanting vacuum evaporationo of the silica film are good. Moreover, the direction which enlarged the difference of the Tsunemitsu refractive index of liquid crystal and an extraordinary index, and made spacing of a liquid crystal cell small makes high responsibility and is desirable. However, since manufacture of a liquid crystal cell becomes difficult so that spacing of a liquid crystal cell becomes small, as for spacing of 0.1 to 0.2, and a liquid crystal cell, it is desirable [the difference of the Tsunemitsu refractive index of liquid crystal, and an extraordinary index] to be referred to as about 2-5 micrometers. What is necessary is for the quality of the material of Electrodes 24a and 24b to have the desirable one where permeability is higher, and just to use transparence electric conduction film, such as ITO film, zinc-oxide film, and a tin oxide film. The ingredient of Electrodes 24a and 24b, physical properties, the formation approach, etc. are explained in full detail like after.
[0016] As mentioned above, although the configuration required for the function to change a wave front using a phase correction component was described, the phase correction component 4 can have the function of a wavelength plate 5 or a polarization beam splitter 2 by carrying out the laminating of the monotonous optical elements, such as a wavelength plate and a polarization hologram, to the phase correction component 4. In this case, assembly and adjustment become simple because the number of the optics which constitute optical head equipment becomes fewer, and productivity improves and is desirable. What is necessary is just to carry out a laminating, after sticking on the glass substrate of a phase correction component directly or sticking a wavelength plate on another glass substrate when carrying out the laminating of the wavelength plate.
[0017] Moreover, it is desirable to consider as the optical head equipment with which the phase correction component and the objective lens are constituted by one. The reason is that the wave aberration (spherical aberration) which the phase correction component generated to the spherical aberration generated with the optical disk will cause a location gap by lens shift, and it

becomes impossible that it amends spherical aberration appropriately when the lens shift which an objective lens moves in a perpendicular field to an optical axis according to tracking etc. is produced and a phase correction component and an objective lens are not one.

[0018] What is necessary is just to carry out fixing a phase correction component to the actuator holding an objective lens etc., in order for a phase correction component and an objective lens to consider as the optical head equipment constituted by one. in this case, the control characteristic of an actuator is not affected — as — making weight of a phase correction component light **** — a signal leader line — light weights, such as a wire, — connection — it is desirable to use an easy thing.

[0019] Next, the approach of amending spherical aberration using the phase correction component in this invention is described. Drawing 3 is the top view showing an example of the voltage drop mold electrode pattern for amending spherical aberration, and is formed in either of the electrodes 24a and 24b shown in drawing 2 . As for 31–33, a low resistance electrode and 30 are high resistance electrodes. Drawing 4 is the top view showing an example of the division electrode pattern for reducing residual aberration, and is formed in the electrode of the direction in which the above-mentioned voltage drop mold electrode pattern is not formed among Electrodes 24a and 24b. Moreover, the core of a low resistance electrode and the core of a division electrode are allotted on an optical axis.

[0020] The slash section in drawing 3 is the high resistance electrode 30 formed with the transparence electric conduction film, for example, is a uniform electrode without division. Black-colored parts are the low resistance electrodes 31–33 for supplying an electrical potential difference to the high resistance electrode 30, and the bore and an outer diameter are arranged in the shape of [centering on an optical axis] a concentric circle. Moreover, the high resistance electrode 30 and the low resistance electrodes 31–33 are connected conductively. Therefore, the high resistance electrode is arranged on adjoining low resistance inter-electrode, and the adjoining low resistance electrode may be connected conductively. That is, the high resistance electrode may be in contact with the low resistance electrode which sandwiches this.

[0021] It connects with the source of a signal which the phase correction component exterior does not illustrate with wiring, and the low resistance electrodes 31–33 can supply the electrical potential difference of arbitration with signals 1–3 respectively. In drawing 4 , 41–47 are segment electrodes which constitute a division electrode, and 48 and 49 are wiring.

[0022] the ratio of sheet resistance rhoH of the electrode material which forms the high resistance electrode to sheet resistance rhoL of the electrode material which forms a low resistance electrode — if rho H/rho L is made or more into 1000, since resistance is low within a low resistance electrode compared with a high resistance electrode, within a low resistance electrode, it will become equipotential. On the other hand, in the field of the high resistance electrode 30, as a result of a feeble current's flowing according to the potential difference between the low resistance electrode 31, 32 and 32, and 33 and a voltage drop's occurring, potential distribution of the axial symmetry mold centering on the optical axis which changes continuously occurs. An electrode material and sheet resistance are explained in full detail later.

[0023] Since the direction of orientation of a liquid crystal molecule changes according to the inter-electrode effective voltage (potential difference) which counters, if it makes all potentials of the division electrode which counters equal, effective-refractive-index distribution of liquid crystal is mostly in agreement with the distribution of voltage generated within the high resistance electrode 30. Therefore, if the low resistance electrodes 31–33 are constituted so that it may correspond to the wave aberration distribution which the distribution of voltage generated within the high resistance electrode 30 should amend, both can offset each other and wave aberration can be amended.

[0024] Drawing 5 is a graph which shows an example of the spherical-aberration amendment by wave aberration generated by the phase correction component in this invention, and is the case where all potentials of the segment electrode which constitutes a division electrode are made equal. The spherical-aberration distribution which requires the amendment which produced A according to thickness fluctuation of an optical disk, the error of optical system, etc., and B are phase contrast distribution for amending the spherical aberration generated by the phase

correction component, and C is the residual aberration distribution which remained after amendment. An axis of abscissa is a pupil radius centering on an optical axis, and is standardized by the radius of incoming beams.
[0025] By setting up suitably the dimension of the low resistance electrodes 31-33, and the applied voltage of signals 1-3, in order to amend the spherical-aberration distribution A, it is opposite, and a configuration offsets the spherical-aberration distribution A according to the almost equivalent phase contrast distribution B, and a sign can amend. The location of the field D in the phase contrast distribution B and Field E is equivalent to the location of the low resistance electrodes 31 (the inside is included) and 32 shown in drawing 3 here, respectively, and since the location of the low resistance electrode 33 is equivalent to a with a pupil radii [of drawing 4] of one or more location, it is not illustrated.
[0026] The wave aberration distribution B which will be generated if the location of the low resistance electrodes 31 and 32 is changed changes. Therefore, in order to amend with high precision, it is required to decide the location and magnitude of the low resistance electrodes 31 and 32 to be in agreement with the configuration of the spherical-aberration distribution A. When the average radius of the inradius of the low resistance electrode 32 of the shape of 0.2 to 0.3 and a circular ring and a circumradius is set [the radius of the incoming beams in a phase correction component side] to 0.7-0.85 for the radius of the low resistance electrode 31 as 1, spherical aberration can be amended efficiently and it is desirable. When the radius of the low resistance electrode 31 is set to 0.21 and the average radius of the low resistance electrode 32 is especially set to 0.74, the greatest amendment effectiveness can be acquired and it is very desirable.
[0027] As mentioned above, although the division electrode was described about the case where it is made equipotential, the residual aberration shown in C of drawing 5 in this case remains. Since the magnitude of this residual aberration is proportional to the magnitude of the spherical aberration to amend, when amending big spherical aberration, such as a gap between layers in a multilayer record disk, it cannot be disregarded. Then, below, the reduction effectiveness of the residual aberration by the phase correction component in this invention is explained.
[0028] The division electrode shown in drawing 4 consists of two or more segment electrodes 41-47 by the shape of a concentric circle acquired by etching the uniform transparence electric conduction film. For example, a photolithography technique and an etching technique can be used for the approach of dividing an electrode. There is no flow between one adjoining segment electrode and other segment electrodes (i.e., the segment inter-electrode from which division spacing differs since the transparence electric conduction film is removed by etching). However, with the phase correction component in this invention, it wires with the transparence electric conduction film inside an electrode so that some segment electrodes may flow, and this is reducing the number of signals.
[0029] That is, two or more segment electrodes are divided into two segment electrode groups, and are connected conductively for every segment electrode group, and it is constituted so that a different electrical potential difference between the electrode of the transparence substrate which counters, and each segment electrode group can be impressed. Thus, by constituting, the number of control voltage generating means can be reduced, and it is desirable.
[0030] In the example shown in drawing 4 , one segment electrode group is formed, and it flows with the wiring 49 arranged on the longitudinal direction of drawing, and connects with the external source of a signal, and the segment electrodes 41, 43, 45, and 47 can impress the electrical potential difference of arbitration with a signal 5. Similarly, other segment electrode groups are formed, and it flows with wiring 48, and connects with the external source of a signal, and the segment electrodes 42, 44, and 46 can impress the electrical potential difference of arbitration with a signal 4.
[0031] Drawing 6 is wave aberration distribution showing the residual aberration at the time of amending spherical aberration using the phase correction component of this invention. The pupil radius is standardized by the incoming beams radius even in this drawing. The residual aberration at the time of making equipotential all the segment electrodes mentioned above is 61, and the residual aberration at the time of supplying a different electrical potential difference as signals 4

and 5 shown in drawing 4 becomes like 62. Fields D41-D47 support the segment electrodes 41, 42-47 here. That is, D41 is a domain (Domain) 41.

[0032] The irregularity of the residual aberration shown in 61 can be graduated by setting up the radius of a segment electrode appropriately according to the configuration of residual aberration, and generating the potential difference in segment inter-electrode, and residual aberration can be reduced. What is necessary is just to enable it to impress here an electrical potential difference which increases the number of signals and is different for every segment electrode to reduce residual aberration further, although the segment electrodes 41, 43, 45, and 47 were made equipotential and differing from this etc. made the segment electrodes 42, 44, and 46 potential. Only the segment electrode 42 is insulated from other segment electrodes as a different pattern from the division electrode pattern shown in drawing 4 , it can connect with the source of a signal of the new exterior, and can also control independently, and although the one number of signals increases, residual aberration is reduced to a pan.

[0033] Next, the electrode material of the phase correction component in this invention is described. the ratio of sheet resistance rhoL of the electrode material which forms the low resistance electrode of a voltage drop mold electrode, and sheet resistance rhoH of the electrode material which forms a high resistance electrode -- rho H/rho L is made or more into 1000. When rhoH is too small, it may become difficult for a comparatively big current to flow also to a high resistance electrode, and for a voltage drop to arise within the low resistance electrode which is in contact with the high resistance electrode, and to acquire desired distribution of voltage. On the other hand, when rhoH is too large, since the conductivity of a high resistance electrode is lost, potential distribution is not generated. Therefore, in order to satisfy the above conditions, rhoH has good 103ohm/** - 107ohms / ** extent. On the other hand, since the permission resistance range of a high resistance electrode becomes large [direction] making it as small as possible as for rhoL, its 1ohm/** - 100ohms / ** extent are preferably good.

[0034] As an ingredient of a low resistance electrode, although metallic materials, such as copper, gold, aluminum, and chromium, are desirable in respect of conductivity and endurance, since it is shaded by the electrode section, permeability falls. Therefore, it is desirable to use the transparence electric conduction film. For example, using small transparence electric conduction film of specific resistance, such as ITO film, satisfies the conditions of the ratio of the resistance of a low resistance electrode and the resistance of a high resistance electrode which were mentioned above, and since permeability is also high, it is desirable. Moreover, transparence electric conduction film like the ITO film is sufficient as the wiring material on the electrode drawer section 27 for impressing an electrical potential difference to a low resistance electrode from an external phase correction component control circuit, and a metal membrane like chromium or nickel is sufficient as it. In the case of a metal connectable [with especially pewters, such as nickel,], the signal line from the outside can be easily connected with a pewter, and it is desirable.

[0035] On the other hand, as an ingredient of a high resistance electrode, it needs to be transparent and sheet resistance needs to be high compared with the ingredient of a low resistance electrode. For example, one sort or the tin oxide film doped two or more sorts, the ITO film, etc. are [elements /, such as a gallium, aluminum, silicon, an yttrium and an indium,] good in elements, such as one sort or zinc oxide film doped two or more sorts, and antimony, an indium, a gallium.

[0036] Since the high resistance film is easily obtained compared with the ITO film, the zinc-oxide film and tin oxide film by which the above-mentioned element was doped are desirable. Especially the zinc oxide film of etching nature with which the above-mentioned element was doped is also good though it is high specific resistance, and it is a suitable ingredient in the optical head equipment of this invention at a point excellent in the permeability of light, and endurance. When using the ITO film for both a low resistance electrode and a high resistance electrode, it is desirable in order for using as the film with which specific resistance differs to tend to control thickness.

[0037] On the other hand, the ingredient of the transparence electric conduction film of a division electrode can use tin oxide, a zinc oxide, etc. with which ITO, a gallium, an indium,

antimony, etc. were doped like the voltage drop mold electrode. However, when membrane resistance is [direction] low and it can do using ITO, since permeability is high, it is desirable.
[0038] Moreover, the above-mentioned low resistance electrode consists of an outside, middle, and three inside low resistance electrodes. The ratio of the average of the inradius of a middle low resistance electrode and circumradius to the pupil radius of the objective lens which constitutes optical head equipment is from 0.7 to 0.85. And by considering as the above optical head equipment the ratio of the difference of the inradius of a middle low resistance electrode and circumradius to the pupil radius of an objective lens is [equipment] from 0.02 to 0.14, since optical head equipment can amend spherical aberration appropriately, it is desirable.
[0039]
[Example] The optical head equipment of this example is equipped with the phase correction component which amends the spherical aberration produced according to thickness fluctuation of an optical disk, an objective lens, the alignment error of optical system, etc. The phase correction component 4 was included in the optical head equipment shown in drawing 1 , and it connected with the phase correction component control circuit 10 which has five sources of an electrical signal electrically. The wavelength of the outgoing radiation light from the semiconductor laser 1 which is the light source is 405nm, NA of an objective lens 6 is 0.85, and a pupil diameter is 3mm in diameter. The component structure of the phase correction component of this example is the same as what was shown in drawing 2 .
[0040] The ITO film of specific resistance 5x10-6 ohm-m was formed by the magnetron sputtering method on the front face with a thickness of 0.5mm which is a transparence substrate of an alkali-free-glass substrate, photolithography and the technique of etching performed patterning on this ITO film, and the division electrode shown in the low resistance electrodes 31-33 and drawing 4 of the voltage drop mold electrode shown in drawing 3 was formed. And it was allotted as the core of a low resistance electrode and the core of a division electrode were on an optical axis.
[0041] The sheet resistance of 50ohm/**, and a division electrode of the sheet resistance of the low resistance electrodes 31-33 is 300ohm/**, and each segment electrode spacing of a division electrode was set to 5 micrometers. Then, to the voltage drop mold electrode, the zinc-oxide film with which the gallium was doped was formed by the magnetron sputtering method, and the transparent high resistance electrode 30 (specific resistance 5x10-3 ohm-m) was formed. The sheet resistance of the high resistance electrode 30 was 1x105ohm/**, and the ratio with the sheet resistance of the low resistance electrodes 31-33 was 2000 to 1. In this example, electrode 24a of drawing 2 was used as the voltage drop mold electrode, and electrode 24b was used as the division electrode.
[0042] Then, after forming in the front face of Electrodes 24a and 24b the insulator layer 25 which uses a silica as a principal component with a spin coat method, similarly the orientation film 26 which uses polyimide as a principal component was formed with the spin coat method. At this time, it piled up so that it might become the cellular structure which shows two produced alkali-free-glass substrates to drawing 2 using the sealant of the epoxy system in which the 4-micrometer glass spacer was mixed. Between the glass substrates of this cel, difference deltan of the Tsunemitsu refractive index and an extraordinary index poured in the pneumatic liquid crystal of 0.15, the inlet was closed, and the liquid crystal cell was formed. In addition, rubbing processing of the orientation film 26 is carried out in advance so that the liquid crystal layer 23 may become homogeneous orientation. Moreover, the coat of the antireflection film (not shown) was carried out to the outside front face of a glass substrate.
[0043] The low resistance electrode 31 the bore of 0.7mm, the outer diameter of 0.8mm, and the low resistance electrode 32 The bore of 2.2mm, The outer diameter of 2.5mm and the low resistance electrode 33 have the shape of a circular ring centering on an optical axis with a bore [of 3.2mm], and an outer diameter of 4.2mm. Wiring formed with the same transparence electric conduction film ingredient connects with the phase correction component control circuit 10 from electrode drawer **** 27, and the electrical potential difference of arbitration can be supplied to each low resistance electrode using signals 1-3. the ratio of the difference (0.15) of the inradius of the middle low resistance electrode 32 and a circumradius -- 0.1 -- it is -- 0.02 and 0.14 --

having done . [as opposed to / the ratio of the average (1.17) of the inradius of the middle low resistance electrode 32 and circumradius to a pupil radius (1.5mm) is 0.78, and are between 0.7 and 0.85 here, and / a pupil radius (1.5mm)]

[0044] On the other hand, the division electrode shown in drawing 4 is divided into the segment electrodes 41-47 of the shape of a concentric circle (the diameter of 0.6mm, 1.0mm, 1.7mm, 2.4mm, 2.6mm, and 2.9mm) from the inside centering on the optical axis. The segment electrodes 41, 43, 45, and 47 have flowed with the wiring 49 formed with the same transparence electric conduction film ingredient, and the equal electrical potential difference was supplied by the signal 5 which the phase correction component control circuit 10 generates. Similarly, the segment electrodes 42, 44, and 46 also flowed with wiring 48, and the equal electrical potential difference was supplied by the signal 4.

[0045] pi The phase correction component in this example was controlled by five electrical signals, an electrical signal is a rectangle alternating current with a frequency of 1kHz, the signal 4 the signals 1 and 2 for voltage drop mold electrodes, three comrades, and for division electrodes and five comrades are in phase respectively, and, as for signals 1, 2, and 3 and signals 4 and 5, the phase has shifted. If it follows, for example, the electrical potential difference of signals 1, 2, and 3 is set to V1 [Vrms], a signal 4, and 5V2 [Vrms], the electrical potential difference impressed to inter-electrode will become V1+V2[Vrms], and will drive a liquid crystal molecule.

[0046] Next, the principle which amends spherical aberration by the phase correction component in this example is explained. B of drawing 5 is a graph which shows radial distribution of the wave aberration (spherical aberration) generated when the thickness of an optical disk becomes thick 0.01mm from 0.1mm of a design value in the optical system whose wavelength of 0.85 and the light source NA of an objective lens is 405nm. Since spherical aberration is axial symmetry, the wave aberration shown in B of drawing 5 should just consider that it is distributed by the pupil radius 0, i.e., an optical axis, as a symmetry axis of rotation inversion.

[0047] In order for a phase correction component to amend the spherical aberration generated by 0.01mm optical disk thickness fluctuation, 1.1Vrms(es) were impressed to 1.3Vrms(es) and the low resistance electrode 32, and electrical-potential-difference 0.5Vrms was impressed to the low resistance electrodes 31 and 33 at the segment electrodes 41-47. Therefore, the effective voltage impressed to a liquid crystal layer was set to 1.6Vrms(es) with 1.8Vrms(es) and the low resistance electrode 32 with the low resistance electrodes 31 and 33, and the distribution of voltage which changes continuously by electrical-potential-difference width-of-face 0.2Vrms into the field of the high resistance electrode 30 produced it. Like the above-mentioned explanation, since the direction of orientation of a liquid crystal molecule is distributed according to an electrical potential difference, as for a phase correction component, concentric circle-like change [wave-front] can be generated, and the radial distribution becomes like B of drawing 4 .

[0048] Since the electrical potential difference of signals 1-3 is decided here according to the magnitude of spherical aberration A, as a result of offsetting each other, the wave aberration on an optical disk side becomes like C, and reduces spherical aberration A and the spherical aberration B generated by the phase correction component. Although the spherical aberration before amendment was abbreviation 0.1lambdarms, as a result of amending using a phase correction component, it decreased to abbreviation 0.018lambdarms.

[0049] What is necessary is on the other hand, just to impress 1.3Vrms(es) to the low resistance electrodes 31 and 33 with A of drawing 5 , at 1.1Vrms(es) and the low resistance electrode 32, in order to amend the spherical aberration which positive/negative reversed when only 0.01mm has the thin thickness of an optical disk. Since wave-front change generated by the phase correction component also becomes the form which reversed the positive/negative of B of drawing 5 by this, spherical aberration can be offset.

[0050] Next, in order to improve the residual aberration after the amendment shown by C of drawing 5 , without changing, among the segment electrodes which constitute a division electrode, 0.48Vrms(es) were impressed to the segment electrodes 41, 43, 45, and 47, and the applied voltage to a voltage drop mold electrode impressed 0.52Vrms(es) to the segment

electrodes 42, 44, and 46. As a result of the electrical-potential-difference difference of 0.04Vrms(es) arising for every segment electrode of a division electrode by this, substantial refractive-index distribution of a liquid crystal layer also changes. 62 of drawing 6 is a graph showing residual aberration when this electrical-potential-difference difference arises, and is expressed as wave aberration. the segment electrodes 41-47 -- signs that residual aberration is decreasing compared with 61 when carrying out 0.5Vrms impression equally to all are known. At this time, as a result of being halved to 0.009lambdarms, record of the information on an optical disk and reproducing characteristics of wave aberration abbreviation 0.018lambdarms after the amendment shown previously improved further.

[0051] Spherical aberration has been amended with a sufficient precision by impressing the electrical potential difference suitable as mentioned above for the low resistance electrodes 31-33 and the segment electrodes 41-47. Moreover, since the low resistance electrodes 31 and 33 do not influence greatly on an optical property even if they impress an always equal electrical potential difference, it can be made to be able to flow through the low resistance electrodes 31 and 33, you may make it able to connect with one power source, and they can be operated with four external signals in this case.

[0052]

[Effect of the Invention] As explained above, it sets to the optical head equipment of this invention. One side of the electrode formed in each of the transparence substrate of the pair which pinches a liquid crystal layer and constitutes a phase correction component The phase correction component which consists of high resistance electrodes with which the low resistance electrode of the three shape of a circular ring arranged in the shape of a concentric circle was matched for low resistance inter-electrode at least, and constitutes the electrode of another side with the division electrode which consists of two or more segment electrodes divided in the shape of a concentric circle is carried.

[0053] Since the phase correction component which has this configuration can generate wave-front change which was mostly in agreement with the spherical-aberration configuration, by using the optical head equipment of this invention which carried this phase correction component, it can amend efficiently the spherical aberration resulting from an optical disk thickness error, and can obtain a good signal light with few noises. Furthermore, since it can be made to operate by few sources of an external signal compared with the former, the optical head equipment of low cost is producible.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] Especially this invention relates to the optical head equipment which performs record and playback of the information on optical recording media, such as an optical disk, about optical head equipment.

[Translation done.]

PRIOR ART

[Description of the Prior Art] In order to raise the recording density of an optical disk in recent years, wavelength of the outgoing radiation light from the semiconductor laser which is the light source is shortened, or enlarging numerical aperture (NA) of an objective lens is put in practical use. It is setting wavelength of the light source to about 405nm, and setting NA to 0.85 in next-generation optical recording, and obtaining bigger recording density is proposed. However, the permissible dose of thickness fluctuation of short-wavelength-izing of the light source and a raise in NA of an objective lens of an optical disk by the cause becomes small.
[0003] Since the spherical aberration proportional to thickness fluctuation of an optical disk occurs, the cause by which these permissible doses become small is because the condensing property of optical head equipment deteriorates and reading of a signal becomes difficult. Moreover, in the case of the multilayer recording method which uses as a record layer the layer from which an optical disk differs, respectively, since the spherical aberration based on class spacing occurs, a means to amend spherical aberration is required.
[0004] The following methods are proposed as a means to amend spherical aberration. One has the method (mechanical control) which negates the spherical aberration which the location of a collimate lens is mechanically changed according to the amount of the generated spherical aberration, is made to generate spherical aberration between objective lenses, and is generated with the thickness error of an optical disk. In the case of this mechanical control, since a part for the mechanical moving part of a collimate lens is needed, there is a fault to which the configuration of optical head equipment becomes intricately or large.
[0005] There is a method (electric system) which amends wave aberration by impressing an electrical potential difference to the phase correction component which it had into the optical path between an objective lens and the light source as another method. In the case of this electric system, since the amount of machine moving part is not compared with a mechanical control, it excels in dependability, such as formation of small lightweight, and vibration. There is JP,10-20263,A as an example which amends wave aberration using a phase correction component. As a method which amends the comatic aberration generated with the inclination of an optical disk in this example, orientation was controlled by changing the electrical potential difference which impresses the liquid crystal pinched between the substrates of the pair which constitutes the phase correction component to a division electrode, and the comatic aberration which the wave front of the transmitted light is changed and is generated is amended.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, it sets to the optical head equipment of this invention, the phase correction component which constitutes one side of the electrode which the transparence substrate of the pair which pinches a liquid-crystal layer and constitutes a phase correction component was alike, respectively, and was formed from a high resistance electrode with which the low resistance electrode of the three shape of a circular ring arranged in the shape of a concentric circle was matched for low resistance inter-electrode at least, and constitutes the electrode of another side with the division electrode which consists of two or more segment electrodes divided in the shape of a concentric circle carries.
[0053] Since the phase correction component which has this configuration can generate wave-front change which was mostly in agreement with the spherical-aberration configuration, by using the optical head equipment of this invention which carried this phase correction component, it can amend efficiently the spherical aberration resulting from an optical disk thickness error, and can obtain a good signal light with few noises. Furthermore, since it can be made to operate by few sources of an external signal compared with the former, the optical head equipment of low cost is producible.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, in the case of the conventional phase correction component, if its attention is paid to one division electrode, since the variation of the wave front of the transmitted light is the same, it will depend for the wave-front configuration acquired on the number of signals impressed to the number of partitions (the number of division electrodes) of an electrode, and a division electrode. Therefore, in order to amend the wave aberration which changes continuously with a sufficient precision, it is necessary to increase the number of division electrodes and to control by many sources of an external signal (external power), and problems, such as complication of a component configuration and an external power configuration, arise. Then, a phase correction component to which it has simple electrode structure and the wave front of the transmitted light is continuously changed by few external powers was desired. The variation of wave aberration like the periphery of spherical aberration was wanted to amend a large field by continuous wave-front change especially.

[Translation done.]

MEANS

[Means for Solving the Problem] It is made in order that this invention may solve the above-mentioned technical problem. The light source, The objective lens for making the outgoing radiation light from the light source condense on an optical recording medium, The phase correction component to which the wave front of the outgoing radiation light prepared between the light source and an objective lens is changed, It is optical head equipment equipped with a control voltage generating means to output the electrical potential difference for changing a wave front to a phase correction component. The phase correction component is equipped with the liquid crystal layer in which the electrode was pinched by the transparence substrate of the pair currently formed in the front face. The electrode of one transparence substrate Connect conductively the adjoining low resistance electrode which is arranged on low resistance inter-electrode at least, and adjoins to the low resistance electrode of the three or more shape of a circular ring allotted in the shape of a concentric circle. It has the high resistance electrode whose ratio of sheet resistance to a low resistance electrode is 1000 or more. The electrode of the transparence substrate of another side The optical head equipment characterized by having the division electrode which consists of two or more segment electrodes with which the flat electrode was divided in the shape of a concentric circle, and the core of a low resistance electrode and the core of a division electrode being on an optical axis is offered.
[0008]
[Embodiment of the Invention] Drawing 1 is the conceptual diagram showing an example of the principle configuration of the optical head equipment of this invention, and performs the record and playback of the information on an optical disk which are an optical recording medium. It becomes parallel light with a collimate lens 3, the quadrant wavelength plate 5 is penetrated after penetrating the phase correction component 4, it is reflected in the direction of 90 degree by the starting mirror 11, and the outgoing radiation light from the semiconductor laser 1 which is the light source is condensed on an optical disk 8 with the objective lens 6 installed in the actuator 7, after penetrating the hologram type polarization beam splitter 2.
[0009] After it is reflected by the optical disk 8 and the condensed light penetrates an objective lens 6, the starting mirror 11, the quadrant wavelength plate 5, the phase correction component 4, and a collimate lens 3 contrary to previously one by one, it is diffracted by the polarization beam splitter 2 and carries out incidence to a photodetector 9. In case the outgoing radiation light from the above-mentioned semiconductor laser 1 is reflected by the optical disk 8, amplitude modulation of the reflected light is carried out by the information recorded on the field of an optical disk 8, and recording information can be read as a signal on the strength [optical] with a photodetector 9. Moreover, when recording information on an optical disk 8, the laser output of semiconductor laser 1 is modulated and information is recorded on the record film of an optical disk 8.
[0010] An electrical potential difference is outputted towards the phase correction component 4 by the phase correction component control circuit 10 which is a control voltage generating means so that the optical disk 8 obtained from a photodetector 9, for example, the reinforcement of a regenerative signal, may become the optimal. The electrical potential difference outputted from the phase correction component control circuit 10 turns into an electrical potential

difference impressed to the electrode of the phase correction component 4 according to the spherical aberration generated from gaps, multilayer optical disks, etc. of optical system, such as a thickness error, an objective lens, etc. of an optical disk.
[0011] Next, the configuration of the phase correction component used in this invention is explained using the sectional view of drawing 2 . Glass substrates 21a and 21b paste up epoxy system resin by the sealant 22 used as a principal component, and the liquid crystal cell is formed. Although acrylic resin, epoxy system resin, vinyl chloride system resin, a polycarbonate, etc. are mentioned as ingredients other than glass with the substrate to be used, points, such as endurance, to a glass substrate is desirable.
[0012] The conductive spacer which carried out the coat of the gold etc. to the glass spacer and the front face of resin is contained in the sealant 22. The coat of the insulator layer 25 which uses electrode 24a, a silica, etc. as a principal component from an inside front face in the inside front face of glass substrate 21a, the insulator layer 25 to which the orientation film 26 uses electrode 24b, a silica, etc. as a principal component from an inside front face in the inside front face of glass substrate 21b again at this order, and the orientation film 26 is carried out to this order. It is an insulator layer 25 and it may exclude for preventing the inter-electrode short-circuit by the conductive foreign matter. Moreover, the coat of the antireflection film may be carried out to the outside front face of glass substrates 21a and 21b.
[0013] Pattern wiring is given so that electrode 24a can be connected with a phase correction component control circuit by the path cord in the electrode drawer section 27. Moreover, electrode 24b has connected above-mentioned gold etc. with electrode 24a formed on glass substrate 21a by the conductive spacer which carried out the coat electrically, therefore electrode 24b is connectable with a phase correction component control circuit in the electrode drawer section 27 with a path cord.
[0014] The interior of a liquid crystal cell is filled up with liquid crystal 23. The ingredient of the liquid crystal to be used has the good pneumatic liquid crystal used for a liquid crystal display etc., and in order for polarization not to change with applied voltage, its uniform homogeneous orientation is desirable. The liquid crystal molecule 28 shown in drawing 2 is in the condition of the homogeneous orientation by which orientation was carried out to the one direction.
[0015] Moreover, as an ingredient of the orientation film, if the pre tilt angle of the liquid crystal molecule 28 becomes 2-10 degrees, it is desirable, and what was parallel to the space of drawing 2 and carried out rubbing of the polyimide film to the longitudinal direction, the thing which carried out the slanting vacuum evaporationo of the silica film are good. Moreover, the direction which enlarged the difference of the Tsunemitsu refractive index of liquid crystal and an extraordinary index, and made spacing of a liquid crystal cell small makes high responsibility and is desirable. However, since manufacture of a liquid crystal cell becomes difficult so that spacing of a liquid crystal cell becomes small, as for spacing of 0.1 to 0.2, and a liquid crystal cell, it is desirable [the difference of the Tsunemitsu refractive index of liquid crystal, and an extraordinary index] to be referred to as about 2-5 micrometers. What is necessary is for the quality of the material of Electrodes 24a and 24b to have the desirable one where permeability is higher, and just to use transparence electric conduction film, such as ITO film, zinc-oxide film, and a tin oxide film. The ingredient of Electrodes 24a and 24b, physical properties, the formation approach, etc. are explained in full detail like after.
[0016] As mentioned above, although the configuration required for the function to change a wave front using a phase correction component was described, the phase correction component 4 can have the function of a wavelength plate 5 or a polarization beam splitter 2 by carrying out the laminating of the monotonous optical elements, such as a wavelength plate and a polarization hologram, to the phase correction component 4. In this case, assembly and adjustment become simple because the number of the optics which constitute optical head equipment becomes fewer, and productivity improves and is desirable. What is necessary is just to carry out a laminating, after sticking on the glass substrate of a phase correction component directly or sticking a wavelength plate on another glass substrate when carrying out the laminating of the wavelength plate.
[0017] Moreover, it is desirable to consider as the optical head equipment with which the phase

correction component and the objective lens are constituted by one. The reason is that the wave aberration (spherical aberration) which the phase correction component generated to the spherical aberration generated with the optical disk will cause a location gap by lens shift, and it becomes impossible that it amends spherical aberration appropriately when the lens shift which an objective lens moves in a perpendicular field to an optical axis according to tracking etc. is produced and a phase correction component and an objective lens are not one.
[0018] What is necessary is just to carry out fixing a phase correction component to the actuator holding an objective lens etc., in order for a phase correction component and an objective lens to consider as the optical head equipment constituted by one. in this case, the control characteristic of an actuator is not affected — as — making weight of a phase correction component light **** — a signal leader line — light weights, such as a wire, — connection — it is desirable to use an easy thing.
[0019] Next, the approach of amending spherical aberration using the phase correction component in this invention is described. Drawing 3 is the top view showing an example of the voltage drop mold electrode pattern for amending spherical aberration, and is formed in either of the electrodes 24a and 24b shown in drawing 2 . As for 31-33, a low resistance electrode and 30 are high resistance electrodes. Drawing 4 is the top view showing an example of the division electrode pattern for reducing residual aberration, and is formed in the electrode of the direction in which the above-mentioned voltage drop mold electrode pattern is not formed among Electrodes 24a and 24b. Moreover, the core of a low resistance electrode and the core of a division electrode are allotted on an optical axis.
[0020] The slash section in drawing 3 is the high resistance electrode 30 formed with the transparence electric conduction film, for example, is a uniform electrode without division. Black-colored parts are the low resistance electrodes 31-33 for supplying an electrical potential difference to the high resistance electrode 30, and the bore and an outer diameter are arranged in the shape of [centering on an optical axis] a concentric circle. Moreover, the high resistance electrode 30 and the low resistance electrodes 31-33 are connected conductively. Therefore, the high resistance electrode is arranged on adjoining low resistance inter-electrode, and the adjoining low resistance electrode may be connected conductively. That is, the high resistance electrode may be in contact with the low resistance electrode which sandwiches this.
[0021] It connects with the source of a signal which the phase correction component exterior does not illustrate with wiring, and the low resistance electrodes 31-33 can supply the electrical potential difference of arbitration with signals 1-3 respectively. In drawing 4 , 41-47 are segment electrodes which constitute a division electrode, and 48 and 49 are wiring.
[0022] the ratio of sheet resistance rhoH of the electrode material which forms the high resistance electrode to sheet resistance rhoL of the electrode material which forms a low resistance electrode — if rho H/rho L is made or more into 1000, since resistance is low within a low resistance electrode compared with a high resistance electrode, within a low resistance electrode, it will become equipotential. On the other hand, in the field of the high resistance electrode 30, as a result of a feeble current's flowing according to the potential difference between the low resistance electrode 31, 32 and 32, and 33 and a voltage drop's occurring, potential distribution of the axial symmetry mold centering on the optical axis which changes continuously occurs. An electrode material and sheet resistance are explained in full detail later.
[0023] Since the direction of orientation of a liquid crystal molecule changes according to the inter-electrode effective voltage (potential difference) which counters, if it makes all potentials of the division electrode which counters equal, effective-refractive-index distribution of liquid crystal is mostly in agreement with the distribution of voltage generated within the high resistance electrode 30. Therefore, if the low resistance electrodes 31-33 are constituted so that it may correspond to the wave aberration distribution which the distribution of voltage generated within the high resistance electrode 30 should amend, both can offset each other and wave aberration can be amended.
[0024] Drawing 5 is a graph which shows an example of the spherical-aberration amendment by wave aberration generated by the phase correction component in this invention, and is the case where all potentials of the segment electrode which constitutes a division electrode are made

equal. The spherical-aberration distribution which requires the amendment which produced A according to thickness fluctuation of an optical disk, the error of optical system, etc., and B are phase contrast distribution for amending the spherical aberration generated by the phase correction component, and C is the residual aberration distribution which remained after amendment. An axis of abscissa is a pupil radius centering on an optical axis, and is standardized by the radius of incoming beams.
[0025] By setting up suitably the dimension of the low resistance electrodes 31-33, and the applied voltage of signals 1-3, in order to amend the spherical-aberration distribution A, it is opposite, and a configuration offsets the spherical-aberration distribution A according to the almost equivalent phase contrast distribution B, and a sign can amend. The location of the field D in the phase contrast distribution B and Field E is equivalent to the location of the low resistance electrodes 31 (the inside is included) and 32 shown in drawing 3 here, respectively, and since the location of the low resistance electrode 33 is equivalent to a with a pupil radii [of drawing 4] of one or more location, it is not illustrated.
[0026] The wave aberration distribution B which will be generated if the location of the low resistance electrodes 31 and 32 is changed changes. Therefore, in order to amend with high precision, it is required to decide the location and magnitude of the low resistance electrodes 31 and 32 to be in agreement with the configuration of the spherical-aberration distribution A. When the average radius of the inradius of the low resistance electrode 32 of the shape of 0.2 to 0.3 and a circular ring and a circumradius is set [the radius of the incoming beams in a phase correction component side] to 0.7-0.85 for the radius of the low resistance electrode 31 as 1, spherical aberration can be amended efficiently and it is desirable. When the radius of the low resistance electrode 31 is set to 0.21 and the average radius of the low resistance electrode 32 is especially set to 0.74, the greatest amendment effectiveness can be acquired and it is very desirable.
[0027] As mentioned above, although the division electrode was described about the case where it is made equipotential, the residual aberration shown in C of drawing 5 in this case remains. Since the magnitude of this residual aberration is proportional to the magnitude of the spherical aberration to amend, when amending big spherical aberration, such as a gap between layers in a multilayer record disk, it cannot be disregarded. Then, below, the reduction effectiveness of the residual aberration by the phase correction component in this invention is explained.
[0028] The division electrode shown in drawing 4 consists of two or more segment electrodes 41-47 by the shape of a concentric circle acquired by etching the uniform transparence electric conduction film. For example, a photolithography technique and an etching technique can be used for the approach of dividing an electrode. There is no flow between one adjoining segment electrode and other segment electrodes (i.e., the segment inter-electrode from which division spacing differs since the transparence electric conduction film is removed by etching). However, with the phase correction component in this invention, it wires with the transparence electric conduction film inside an electrode so that some segment electrodes may flow, and this is reducing the number of signals.
[0029] That is, two or more segment electrodes are divided into two segment electrode groups, and are connected conductively for every segment electrode group, and it is constituted so that a different electrical potential difference between the electrode of the transparence substrate which counters, and each segment electrode group can be impressed. Thus, by constituting, the number of control voltage generating means can be reduced, and it is desirable.
[0030] In the example shown in drawing 4 , one segment electrode group is formed, and it flows with the wiring 49 arranged on the longitudinal direction of drawing, and connects with the external source of a signal, and the segment electrodes 41, 43, 45, and 47 can impress the electrical potential difference of arbitration with a signal 5. Similarly, other segment electrode groups are formed, and it flows with wiring 48, and connects with the external source of a signal, and the segment electrodes 42, 44, and 46 can impress the electrical potential difference of arbitration with a signal 4.
[0031] Drawing 6 is wave aberration distribution showing the residual aberration at the time of amending spherical aberration using the phase correction component of this invention. The pupil

radius is standardized by the incoming beams radius even in this drawing. The residual aberration at the time of making equipotential all the segment electrodes mentioned above is 61, and the residual aberration at the time of supplying a different electrical potential difference as signals 4 and 5 shown in drawing 4 becomes like 62. Fields D41-D47 support the segment electrodes 41, 42-47 here. That is, D41 is a domain (Domain) 41.
[0032] The irregularity of the residual aberration shown in 61 can be graduated by setting up the radius of a segment electrode appropriately according to the configuration of residual aberration, and generating the potential difference in segment inter-electrode, and residual aberration can be reduced. What is necessary is just to enable it to impress here an electrical potential difference which increases the number of signals and is different for every segment electrode to reduce residual aberration further, although the segment electrodes 41, 43, 45, and 47 were made equipotential and differing from this etc. made the segment electrodes 42, 44, and 46 potential. Only the segment electrode 42 is insulated from other segment electrodes as a different pattern from the division electrode pattern shown in drawing 4 , it can connect with the source of a signal of the new exterior, and can also control independently, and although the one number of signals increases, residual aberration is reduced to a pan.
[0033] Next, the electrode material of the phase correction component in this invention is described. the ratio of sheet resistance rhoL of the electrode material which forms the low resistance electrode of a voltage drop mold electrode, and sheet resistance rhoH of the electrode material which forms a high resistance electrode — rho H/rho L is made or more into 1000. When rhoH is too small, it may become difficult for a comparatively big current to flow also to a high resistance electrode, and for a voltage drop to arise within the low resistance electrode which is in contact with the high resistance electrode, and to acquire desired distribution of voltage. On the other hand, when rhoH is too large, since the conductivity of a high resistance electrode is lost, potential distribution is not generated. Therefore, in order to satisfy the above conditions, rhoH has good 103ohm/** - 107ohms / ** extent. On the other hand, since the permission resistance range of a high resistance electrode becomes large [direction] making it as small as possible as for rhoL, its 1ohm/** - 100ohms / ** extent are preferably good.
[0034] As an ingredient of a low resistance electrode, although metallic materials, such as copper, gold, aluminum, and chromium, are desirable in respect of conductivity and endurance, since it is shaded by the electrode section, permeability falls. Therefore, it is desirable to use the transparence electric conduction film. For example, using small transparence electric conduction film of specific resistance, such as ITO film, satisfies the conditions of the ratio of the resistance of a low resistance electrode and the resistance of a high resistance electrode which were mentioned above, and since permeability is also high, it is desirable. Moreover, transparence electric conduction film like the ITO film is sufficient as the wiring material on the electrode drawer section 27 for impressing an electrical potential difference to a low resistance electrode from an external phase correction component control circuit, and a metal membrane like chromium or nickel is sufficient as it. In the case of a metal connectable [with especially pewters, such as nickel,], the signal line from the outside can be easily connected with a pewter, and it is desirable.
[0035] On the other hand, as an ingredient of a high resistance electrode, it needs to be transparent and sheet resistance needs to be high compared with the ingredient of a low resistance electrode. For example, one sort or the tin oxide film doped two or more sorts, the ITO film, etc. are [elements /, such as a gallium, aluminum, silicon, an yttrium and an indium,] good in elements, such as one sort or zinc oxide film doped two or more sorts, and antimony, an indium, a gallium.
[0036] Since the high resistance film is easily obtained compared with the ITO film, the zinc-oxide film and tin oxide film by which the above-mentioned element was doped are desirable. Especially the zinc oxide film of etching nature with which the above-mentioned element was doped is also good though it is high specific resistance, and it is a suitable ingredient in the optical head equipment of this invention at a point excellent in the permeability of light, and endurance. When using the ITO film for both a low resistance electrode and a high resistance electrode, it is desirable in order for using as the film with which specific resistance differs to

tend to control thickness.
[0037] On the other hand, the ingredient of the transparence electric conduction film of a division electrode can use tin oxide, a zinc oxide, etc. with which ITO, a gallium, an indium, antimony, etc. were doped like the voltage drop mold electrode. However, when membrane resistance is [direction] low and it can do using ITO, since permeability is high, it is desirable.
[0038] Moreover, the above-mentioned low resistance electrode consists of an outside, middle, and three inside low resistance electrodes. The ratio of the average of the inradius of a middle low resistance electrode and circumradius to the pupil radius of the objective lens which constitutes optical head equipment is from 0.7 to 0.85. And by considering as the above optical head equipment the ratio of the difference of the inradius of a middle low resistance electrode and circumradius to the pupil radius of an objective lens is [equipment] from 0.02 to 0.14, since optical head equipment can amend spherical aberration appropriately, it is desirable.

[Translation done.]

EXAMPLE

[Example] The optical head equipment of this example is equipped with the phase correction component which amends the spherical aberration produced according to thickness fluctuation of an optical disk, an objective lens, the alignment error of optical system, etc. The phase correction component 4 was included in the optical head equipment shown in drawing 1 , and it connected with the phase correction component control circuit 10 which has five sources of an electrical signal electrically. The wavelength of the outgoing radiation light from the semiconductor laser 1 which is the light source is 405nm, NA of an objective lens 6 is 0.85, and a pupil diameter is 3mm in diameter. The component structure of the phase correction component of this example is the same as what was shown in drawing 2 .
[0040] The ITO film of specific resistance 5x10-6 ohm-m was formed by the magnetron sputtering method on the front face with a thickness of 0.5mm which is a transparence substrate of an alkali-free-glass substrate, photolithography and the technique of etching performed patterning on this ITO film, and the division electrode shown in the low resistance electrodes 31-33 and drawing 4 of the voltage drop mold electrode shown in drawing 3 was formed. And it was allotted as the core of a low resistance electrode and the core of a division electrode were on an optical axis.
[0041] The sheet resistance of 50ohm/**, and a division electrode of the sheet resistance of the low resistance electrodes 31-33 is 300ohm/**, and each segment electrode spacing of a division electrode was set to 5 micrometers. Then, to the voltage drop mold electrode, the zinc-oxide film with which the gallium was doped was formed by the magnetron sputtering method, and the transparent high resistance electrode 30 (specific resistance 5x10-3 ohm-m) was formed. The sheet resistance of the high resistance electrode 30 was 1x105ohm/**, and the ratio with the sheet resistance of the low resistance electrodes 31-33 was 2000 to 1. In this example, electrode 24a of drawing 2 was used as the voltage drop mold electrode, and electrode 24b was used as the division electrode.
[0042] Then, after forming in the front face of Electrodes 24a and 24b the insulator layer 25 which uses a silica as a principal component with a spin coat method, similarly the orientation film 26 which uses polyimide as a principal component was formed with the spin coat method. At this time, it piled up so that it might become the cellular structure which shows two produced alkali-free-glass substrates to drawing 2 using the sealant of the epoxy system in which the 4-micrometer glass spacer was mixed. Between the glass substrates of this cel, difference deltan of the Tsunemitsu refractive index and an extraordinary index poured in the pneumatic liquid crystal of 0.15, the inlet was closed, and the liquid crystal cell was formed. In addition, rubbing processing of the orientation film 26 is carried out in advance so that the liquid crystal layer 23 may become homogeneous orientation. Moreover, the coat of the antireflection film (not shown) was carried out to the outside front face of a glass substrate.
[0043] The low resistance electrode 31 the bore of 0.7mm, the outer diameter of 0.8mm, and the low resistance electrode 32 The bore of 2.2mm, The outer diameter of 2.5mm and the low resistance electrode 33 have the shape of a circular ring centering on an optical axis with a bore [of 3.2mm], and an outer diameter of 4.2mm. Wiring formed with the same transparence electric conduction film ingredient connects with the phase correction component control circuit 10 from

electrode drawer **** 27, and the electrical potential difference of arbitration can be supplied to each low resistance electrode using signals 1-3. the ratio of the difference (0.15) of the inradius of the middle low resistance electrode 32 and a circumradius — 0.1 — it is — 0.02 and 0.14 — having done . [as opposed to / the ratio of the average (1.17) of the inradius of the middle low resistance electrode 32 and circumradius to a pupil radius (1.5mm) is 0.78, and are between 0.7 and 0.85 here, and / a pupil radius (1.5mm)]
[0044] On the other hand, the division electrode shown in drawing 4 is divided into the segment electrodes 41-47 of the shape of a concentric circle (the diameter of 0.6mm, 1.0mm, 1.7mm, 2.4mm, 2.6mm, and 2.9mm) from the inside centering on the optical axis. The segment electrodes 41, 43, 45, and 47 have flowed with the wiring 49 formed with the same transparence electric conduction film ingredient, and the equal electrical potential difference was supplied by the signal 5 which the phase correction component control circuit 10 generates. Similarly, the segment electrodes 42, 44, and 46 also flowed with wiring 48, and the equal electrical potential difference was supplied by the signal 4.
[0045] pi The phase correction component in this example was controlled by five electrical signals, an electrical signal is a rectangle alternating current with a frequency of 1kHz, the signal 4 the signals 1 and 2 for voltage drop mold electrodes, three comrades, and for division electrodes and five comrades are in phase respectively, and, as for signals 1, 2, and 3 and signals 4 and 5, the phase has shifted. If it follows, for example, the electrical potential difference of signals 1, 2, and 3 is set to V1 [Vrms], a signal 4, and 5V2 [Vrms], the electrical potential difference impressed to inter-electrode will become V1+V2[Vrms], and will drive a liquid crystal molecule.
[0046] Next, the principle which amends spherical aberration by the phase correction component in this example is explained. B of drawing 5 is a graph which shows radial distribution of the wave aberration (spherical aberration) generated when the thickness of an optical disk becomes thick 0.01mm from 0.1mm of a design value in the optical system whose wavelength of 0.85 and the light source NA of an objective lens is 405nm. Since spherical aberration is axial symmetry, the wave aberration shown in B of drawing 5 should just consider that it is distributed by the pupil radius 0, i.e., an optical axis, as a symmetry axis of rotation inversion.
[0047] In order for a phase correction component to amend the spherical aberration generated by 0.01mm optical disk thickness fluctuation, 1.1Vrms(es) were impressed to 1.3Vrms(es) and the low resistance electrode 32, and electrical-potential-difference 0.5Vrms was impressed to the low resistance electrodes 31 and 33 at the segment electrodes 41-47. Therefore, the effective voltage impressed to a liquid crystal layer was set to 1.6Vrms(es) with 1.8Vrms(es) and the low resistance electrode 32 with the low resistance electrodes 31 and 33, and the distribution of voltage which changes continuously by electrical-potential-difference width-of-face 0.2Vrms into the field of the high resistance electrode 30 produced it. Like the above-mentioned explanation, since the direction of orientation of a liquid crystal molecule is distributed according to an electrical potential difference, as for a phase correction component, concentric circle-like change [wave-front] can be generated, and the radial distribution becomes like B of drawing 4 .

[0048] Since the electrical potential difference of signals 1-3 is decided here according to the magnitude of spherical aberration A, as a result of offsetting each other, the wave aberration on an optical disk side becomes like C, and reduces spherical aberration A and the spherical aberration B generated by the phase correction component. Although the spherical aberration before amendment was abbreviation 0.1lambdarms, as a result of amending using a phase correction component, it decreased to abbreviation 0.018lambdarms.
[0049] What is necessary is on the other hand, just to impress 1.3Vrms(es) to the low resistance electrodes 31 and 33 with A of drawing 5 , at 1.1Vrms(es) and the low resistance electrode 32, in order to amend the spherical aberration which positive/negative reversed when only 0.01mm has the thin thickness of an optical disk. Since wave-front change generated by the phase correction component also becomes the form which reversed the positive/negative of B of drawing 5 by this, spherical aberration can be offset.
[0050] Next, in order to improve the residual aberration after the amendment shown by C of

drawing 5 , without changing, among the segment electrodes which constitute a division electrode, 0.48Vrms(es) were impressed to the segment electrodes 41, 43, 45, and 47, and the applied voltage to a voltage drop mold electrode impressed 0.52Vrms(es) to the segment electrodes 42, 44, and 46. As a result of the electrical-potential-difference difference of 0.04Vrms(es) arising for every segment electrode of a division electrode by this, substantial refractive-index distribution of a liquid crystal layer also changes. 62 of drawing 6 is a graph showing residual aberration when this electrical-potential-difference difference arises, and is expressed as wave aberration. the segment electrodes 41-47 -- signs that residual aberration is decreasing compared with 61 when carrying out 0.5Vrms impression equally to all are known. At this time, as a result of being halved to 0.009lambdarms, record of the information on an optical disk and reproducing characteristics of wave aberration abbreviation 0.018lambdarms after the amendment shown previously improved further.

[0051] Spherical aberration has been amended with a sufficient precision by impressing the electrical potential difference suitable as mentioned above for the low resistance electrodes 31-33 and the segment electrodes 41-47. Moreover, since the low resistance electrodes 31 and 33 do not influence greatly on an optical property even if they impress an always equal electrical potential difference, it can be made to be able to flow through the low resistance electrodes 31 and 33, you may make it able to connect with one power source, and they can be operated with four external signals in this case.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The conceptual diagram showing an example of the principle configuration of the optical head equipment of this invention.
[Drawing 2] The sectional view showing an example of the configuration of the phase correction component in this invention.
[Drawing 3] The top view showing an example of the voltage drop mold electrode pattern of the phase correction component in this invention.
[Drawing 4] The top view showing an example of the division electrode pattern of the phase correction component in this invention.
[Drawing 5] The graph which shows an example of the spherical-aberration amendment by the wave aberration generated by the phase correction component at the time of impressing the same electrical potential difference as the segment electrode which constitutes the division electrode in this invention. (The field in which the spherical aberration which takes amendment to A, wave-front change which generated B by the phase correction component, and C are equivalent to the wave aberration after amendment, and D is equivalent to the low resistance electrode 31, field in which E is equivalent to the low resistance electrode 32)
[Drawing 6] The graph which shows an example of the spherical-aberration amendment by the wave aberration generated by the phase correction component when two or more electrical potential differences were impressed to the segment electrode which constitutes the division electrode in this invention. D41-D47 are a field equivalent to the segment electrodes 41-47.
[Description of Notations]
1: Semiconductor laser
2: Polarization beam splitter
3: Collimate lens
4: Phase correction component
1/5:4 wavelength plate
6: Objective lens
7: Actuator
8: Optical disk
9: Photodetector
10: Phase correction component control circuit
21a, 21b: Glass substrate
22: Sealant
23: Liquid crystal layer
24a, 24b: Electrode
25: Insulator layer
26: Orientation film
27: Electrode drawer section
28: Liquid crystal molecule
30: High resistance electrode
31-33: Low resistance electrode

41-47: Segment electrode
48 49: Wiring
61 62: Residual wave aberration

[Translation done.]

* NOTICES *

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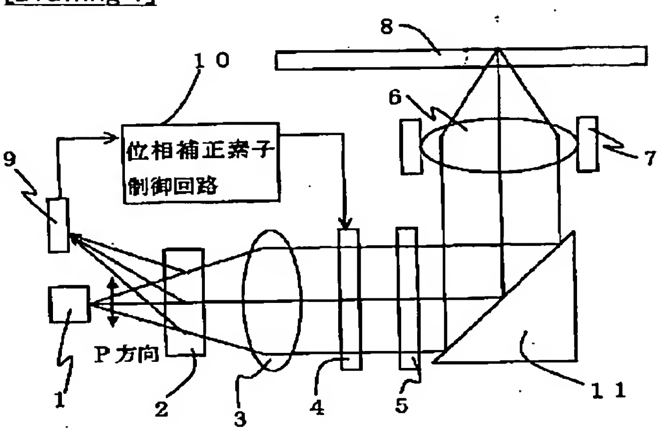
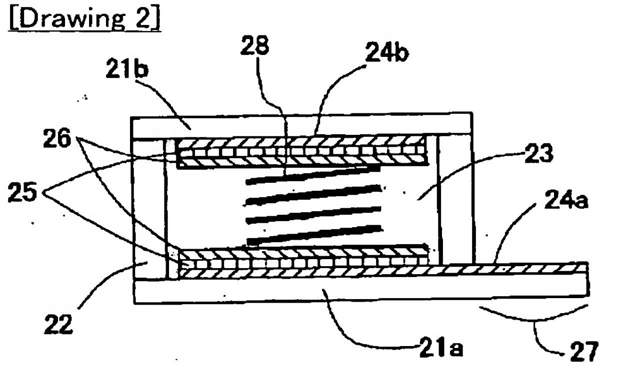
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

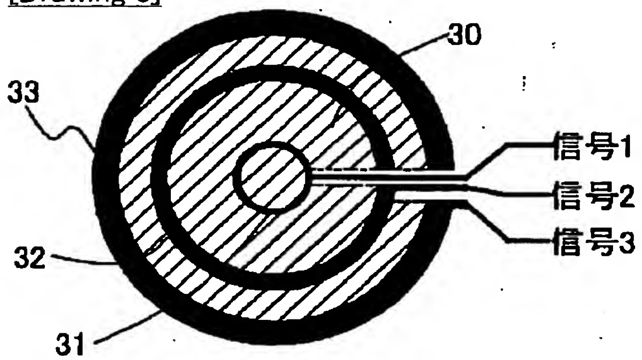
[Drawing 1]



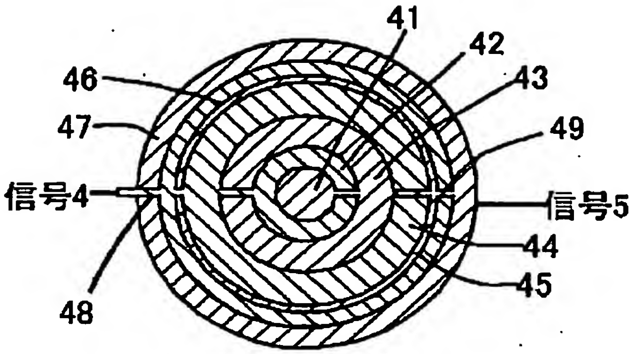
[Drawing 2]



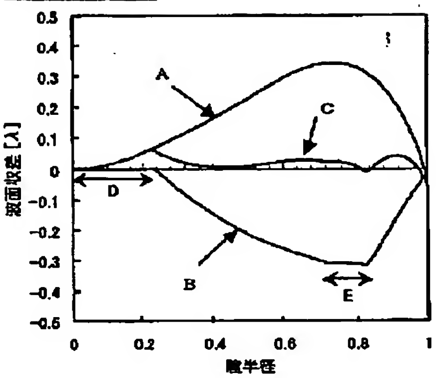
[Drawing 3]



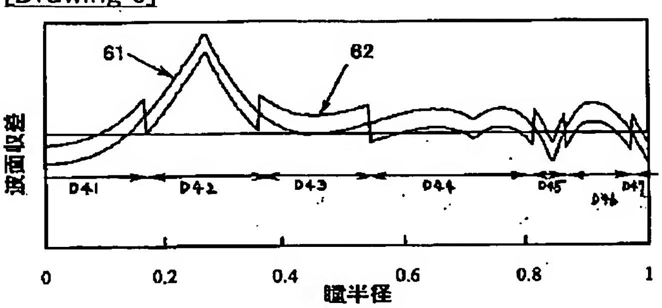
[Drawing 4]



[Drawing 5]



[Drawing 6]



[Translation done.]

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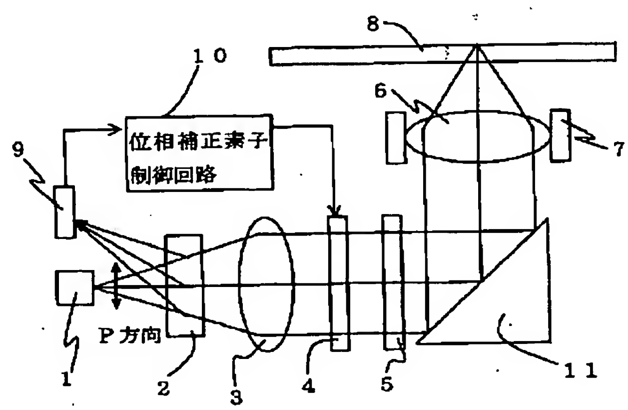
(54)【発明の名称】 光ヘッド装置

(57)【要約】
【課題】光ディスク厚み誤差に起因する球面収差を効率よく補正でき、ノイズの少ない良好な信号光が得られる光ヘッド装置とする。
【解決手段】電極を表面に有する一対の基板に挟持された液晶層を備え、一方の基板の電極は、同心円状である３つの円環状の低抵抗電極と、隣接する低抵抗電極間に配されていて低抵抗電極とのシート抵抗値の比が１０００以上の高抵抗電極とを備え、他方の基板の電極は、平面電極が同心円状に分割された複数のセグメント電極からなる分割電極を備え、かつ低抵抗電極および分割電極の各々の中心を通る光軸が一致する位相補正素子４を得て、この素子を光ヘッド装置の光源１と対物レンズ６との間の光路中に設置する。



【特許請求の範囲】

【請求項１】光源と、光源からの出射光を光記録媒体上に集光させるための対物レンズと、光源と対物レンズとの間に設けられた出射光の波面を変化させる位相補正素子と、波面を変化させるための電圧を位相補正素子へ出力する制御電圧発生手段とを備える光ヘッド装置であって、位相補正素子は電極が表面に形成されている一対の透明基板に挟持された液晶層を備えており、

一方の透明基板の電極は、同心円状に配されている３つ以上の円環状の低抵抗電極と、隣接する少なくとも低抵抗電極間に配されていて隣接する低抵抗電極を導電接続する、低抵抗電極に対するシート抵抗値の比が１０００以上である高抵抗電極とを備え、

他方の透明基板の電極は、平面電極が同心円状に分割された複数のセグメント電極からなる分割電極を備え、

かつ低抵抗電極の中心と分割電極の中心とが光軸上にあることを特徴とする光ヘッド装置。

【請求項２】前記複数のセグメント電極が２つのセグメント電極群に分けられ、それぞれのセグメント電極群ごとに導電接続されて、対向する透明基板の電極とそれぞれのセグメント電極群との間に異なる電圧が印加できるように構成されている請求項１記載の光ヘッド装置。

【請求項３】前記低抵抗電極は外側、中間、内側の３つの低抵抗電極からなり、前記対物レンズの瞳半径に対する中間低抵抗電極の内半径と外半径との平均値の比が０．７から０．８５までであり、かつ前記対物レンズの瞳半径に対する前記内半径と前記外半径との差の比が０．０２から０．１４までである請求項１または２記載の光ヘッド装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光ヘッド装置に関し、特に光ディスクなどの光記録媒体の情報の記録・再生を行う光ヘッド装置に関する。

【０００２】

【従来の技術】近年、光ディスクの記録密度を高めるために、光源である半導体レーザからの出射光の波長を短くしたり、対物レンズの開口数（ＮＡ）を大きくすることが実用化されている。次世代の光記録においては光源の波長を４０５ｎｍ程度、ＮＡを０．８５とすることで、より大きな記録密度を得ることが提案されている。しかし、光源の短波長化や対物レンズの高ＮＡ化が原因で、光ディスクの厚み変動の許容量が小さくなる。

【０００３】これら許容量が小さくなる原因は、光ディスクの厚み変動に比例した球面収差が発生するために、光ヘッド装置の集光特性が劣化して信号の読み取りが困難になることによる。また、光ディスクの異なる層をそれぞれ記録層とする多層記録方式の場合、各層間隔に基く球面収差が発生するため球面収差を補正する手段が必要である。

【０００４】球面収差を補正する手段として以下の方式が提案されている。一つは発生した球面収差の量に応じてコリメートレンズの位置を機械的に変化させ対物レンズとの間で球面収差を発生させ、光ディスクの厚み誤差で発生する球面収差を打ち消す方式（機械方式）がある。この機械方式の場合、コリメートレンズの機械的可動部分を必要とするため光ヘッド装置の構成が複雑または大きくなる欠点がある。

【０００５】別の方式として、対物レンズと光源との間の光路中に備えた位相補正素子に電圧を印加することにより波面収差を補正する方式（電気方式）がある。この電気方式の場合、機械方式に比べ機械可動部分がないことから小型軽量化や振動などの信頼性において優れている。位相補正素子を用いて波面収差を補正する例としては特開平１０－２０２６３がある。この例では光ディスクの傾きにより発生するコマ収差を補正する方式として、位相補正素子を構成している一対の基板間に挟持された液晶を、分割電極に印加する電圧を変化させることで配向を制御し、透過光の波面を変化させて発生するコマ収差を補正している。

【０００６】

【発明が解決しようとする課題】しかし、従来の位相補正素子の場合、１つの分割電極に着目すると透過光の波面の変化量は同じであるため、得られる波面形状は電極の分割数（分割電極数）および分割電極に印加する信号数に依存する。したがって、連続的に変化する波面収差を精度良く補正するためには、分割電極数を増やし多数の外部信号源（外部電源）で制御する必要があり、素子構成、外部電源構成の複雑化などの問題が生ずる。そこで、単純な電極構造を有し、かつ少ない外部電源により透過光の波面を連続的に変化させる位相補正素子が望まれていた。特に、球面収差の周辺部のような波面収差の変化量が大きい領域を連続的な波面変化で補正することが望まれていた。

【０００７】

【課題を解決するための手段】本発明は、上記の課題を解決するためになされたものであり、光源と、光源からの出射光を光記録媒体上に集光させるための対物レンズと、光源と対物レンズとの間に設けられた出射光の波面を変化させる位相補正素子と、波面を変化させるための電圧を位相補正素子へ出力する制御電圧発生手段とを備える光ヘッド装置であって、位相補正素子は電極が表面に形成されている一対の透明基板に挟持された液晶層を備えており、一方の透明基板の電極は、同心円状に配されている３つ以上の円環状の低抵抗電極と、隣接する少なくとも低抵抗電極間に配されていて隣接する低抵抗電極を導電接続する、低抵抗電極に対するシート抵抗値の比が１０００以上である高抵抗電極とを備え、他方の透明基板の電極は、平面電極が同心円状に分割された複数のセグメント電極からなる分割電極を備え、かつ低抵抗電極

電極の中心と分割電極の中心とが光軸上にあることを特徴とする光ヘッド装置を提供する。

【０００８】

【発明の実施の形態】図１は、本発明の光ヘッド装置の原理構成の一例を示す概念図であり、光記録媒体である光ディスクの情報の記録および再生を行うものである。光源である半導体レーザ１からの出射光は例えばホログラムタイプの偏光ビームスプリッタ２を透過した後、コリメートレンズ３により平行光となり、位相補正素子４を透過後、４分の１波長板５を透過し、立ち上げミラー１１で９０°方向に反射され、アクチュエータ７に設置された対物レンズ６により光ディスク８上に集光される。

【０００９】集光された光は、光ディスク８により反射され対物レンズ６、立ち上げミラー１１、４分の１波長板５、位相補正素子４、コリメートレンズ３を順次先程とは逆に透過した後、偏光ビームスプリッタ２により回折され光検出器９に入射する。前述の半導体レーザ１からの出射光が光ディスク８により反射される際、光ディスク８の面上に記録された情報により反射光は振幅変調され、光検出器９により光強度信号として記録情報を読み取ることができる。また、光ディスク８に情報を記録するときには、半導体レーザ１のレーザ出力を変調させ、光ディスク８の記録膜に情報を記録する。

【００１０】光検出器９より得られる光ディスク８の、例えば再生信号の強度が最適となるように、位相補正素子４に向けて制御電圧発生手段である位相補正素子制御回路１０により電圧が出力される。位相補正素子制御回路１０より出力される電圧は、光ディスクの厚み誤差や対物レンズなど光学系のズレや多層光ディスクなどから発生する球面収差に応じて位相補正素子４の電極に印加する電圧となる。

【００１１】次に本発明において使用する位相補正素子の構成を図２の断面図を用いて説明する。ガラス基板２１ａ、２１ｂが、例えばエポキシ系樹脂を主成分とするシール材２２により接着され液晶セルが形成されている。使用する基板でガラス以外の材料としては、アクリル系樹脂、エポキシ系樹脂、塩化ビニル系樹脂、ポリカーボネートなどが挙げられるが、耐久性などの点からガラス基板が好ましい。

【００１２】シール材２２には例えばガラス製のスペーサと例えば樹脂の表面に金などを被膜した導電性スペーサが含まれている。ガラス基板２１ａの内側表面には、内側表面から電極２４ａ、シリカなどを主成分とする絶縁膜２５、配向膜２６がこの順に、またガラス基板２１ｂの内側表面には、内側表面から電極２４ｂ、シリカなどを主成分とする絶縁膜２５、配向膜２６がこの順に被膜されている。絶縁膜２５は導電性異物による電極間ショートを防止するためのものであり省いてもよい。また、ガラス基板２１ａ、２１ｂの外側表面に反射防止膜が被膜されていてもよい。

【００１３】電極２４ａは電極引出部２７で接続線によって位相補正素子制御回路と接続できるようパターン配線が施されている。また電極２４ｂは上述の金などを被膜した導電性スペーサによりガラス基板２１ａ上に形成された電極２４ａと電気的に接続しており、したがって、電極２４ｂは電極引出部２７で接続線によって位相補正素子制御回路と接続できる。

【００１４】液晶セル内部には液晶２３が充填されている。使用する液晶の材料は、液晶ディスプレイなどに用いられるネマティック液晶がよく、印加電圧により偏光が変化しないためには一様なホモジニアス配向が好ましい。図２に示した液晶分子２８は、一方向に配向されたホモジニアス配向の状態にある。

【００１５】また配向膜の材料としては、液晶分子２８のプレチルト角が２～１０°となれば好ましく、ポリイミド膜を図２の紙面に平行で左右方向にラビングしたものや、シリカ膜を斜め蒸着したものなどがよい。また、液晶の常光屈折率と異常光屈折率との差を大きくして液晶セルの間隔を小さくした方が応答性を高くでき好ましい。しかし、液晶セルの間隔が小さくなるほど液晶セルの製作が困難になるため、液晶の常光屈折率と異常光屈折率との差は０．１～０．２、液晶セルの間隔は２～５μｍ程度とすることが好ましい。電極２４ａ、２４ｂの材質は透過率が高い方が望ましく、ＩＴＯ膜、酸化亜鉛膜、酸化錫膜などの透明導電膜を使用すればよい。電極２４ａ、２４ｂの材料、物性、形成方法などは後ほど詳述する。

【００１６】以上、位相補正素子を用いて波面を変化させる機能に必要な構成を述べたが、波長板や偏光ホログラムなどの平板光学素子を位相補正素子４に積層することにより、波長板５や偏光ビームスプリッタ２の機能を位相補正素子４が併せ持つようにできる。この場合、光ヘッド装置を構成する光学部品の数が減ることで組立、調整が簡易となり、生産性が向上して好ましい。波長板を積層するときは、位相補正素子のガラス基板に直接貼り合せるか、または波長板を別のガラス基板に貼り合わせた後積層すればよい。

【００１７】また、位相補正素子と対物レンズとが一体に構成されている光ヘッド装置とすることが好ましい。その理由は、トラッキングなどにより対物レンズが光軸に対して垂直な面内で移動するレンズシフトを生じたとき、位相補正素子と対物レンズが一体でない場合、光ディスクにより発生した球面収差に対して位相補正素子が発生した波面収差（球面収差）がレンズシフト分だけ位置ずれを起こすことになり、球面収差を適切に補正できなくなるからである。

【００１８】位相補正素子と対物レンズとが一体に構成されている光ヘッド装置とするには、対物レンズを保持しているアクチュエータに位相補正素子を固定するなど

すればよい。この場合、アクチュエータの制御特性に影響を与えないように、位相補正素子の重量を軽くしたり、信号引出線をワイヤなどの軽量で接続容易なものを使用することが好ましい。

【００１９】次に、本発明における位相補正素子を用いて球面収差を補正する方法に関して述べる。図３は球面収差を補正するための電圧降下型電極パターンの一例を示す平面図であり、図２に示された電極２４ａ、２４ｂのいずれか一方に形成されている。３１～３３は低抵抗電極、３０は高抵抗電極である。図４は残留収差を低減するための分割電極パターンの一例を示す平面図であり、電極２４ａ、２４ｂのうち、上記の電圧降下型電極パターンが形成されていない方の電極に形成されている。また、低抵抗電極の中心と分割電極の中心は光軸上に配される。

【００２０】図３における斜線部は透明導電膜により形成された高抵抗電極３０であり、例えば分割のない一様な電極である。黒塗部分は高抵抗電極３０に電圧を供給するための低抵抗電極３１～３３であり、その内径、外径が光軸を中心とする同心円状に配置されている。また、高抵抗電極３０と低抵抗電極３１～３３は導電接続されている。したがって、隣接する低抵抗電極間に高抵抗電極が配されていて、隣接する低抵抗電極が導電接続されていてもよい。すなわち、高抵抗電極がこれを挟む低抵抗電極と接していてもよい。

【００２１】低抵抗電極３１～３３は配線により位相補正素子外部の図示しない信号源と接続されており各々信号１～３によって任意の電圧を供給できる。図４において、４１～４７は分割電極を構成するセグメント電極であり、４８と４９は配線である。

【００２２】低抵抗電極を形成する電極材料のシート抵抗ρ_Lに対する高抵抗電極を形成する電極材料のシート抵抗ρ_Hの比$\rho_H／\rho_L$を１０００以上にすると、高抵抗電極に比べ低抵抗電極内では抵抗が低いため低抵抗電極内では等電位となる。一方、高抵抗電極３０の面内では低抵抗電極３１と３２、および３２と３３間の電位差により微弱な電流が流れて電圧降下が発生する結果、連続的に変化する光軸を中心とした軸対称型の電位分布が発生する。電極材料およびシート抵抗に関しては後程詳述する。

【００２３】液晶分子の配向方向は、対向する電極間の実効電圧（電位差）に応じて変化するため、対向する分割電極の電位を全て等しくすれば、液晶の実効屈折率分布は高抵抗電極３０内で発生する電圧分布にほぼ一致する。したがって、高抵抗電極３０内で発生する電圧分布が補正すべき波面収差分布に対応するよう低抵抗電極３１～３３を構成すれば、両者が相殺でき波面収差を補正できる。

【００２４】図５は本発明における位相補正素子により発生した、波面収差による球面収差補正の一例を示すグラフであり、分割電極を構成するセグメント電極の電位を全て等しくした場合である。Ａは光ディスクの厚み変動や光学系の誤差などにより生じた補正を要する球面収差分布、Ｂは位相補正素子により発生する球面収差を補正するための位相差分布であり、Ｃは補正後に残った残留収差分布である。横軸は光軸を中心とした瞳半径であり、入射光束の半径により規格化されている。

【００２５】球面収差分布Ａを補正するために低抵抗電極３１～３３の寸法、および信号１～３の印加電圧を適宜設定することで、符号が反対で形状がほぼ同等な位相差分布Ｂにより球面収差分布Ａを相殺して補正できる。ここで、位相差分布Ｂにおける領域Ｄと領域Ｅの位置は、図３に示す低抵抗電極３１（内側を含む）と３２の位置にそれぞれ対応しており、低抵抗電極３３の位置は図４の瞳半径１以上の位置に対応するため図示されていない。

【００２６】低抵抗電極３１と３２の位置を変化させると発生する波面収差分布Ｂもまた変化する。したがって、高精度に補正するためには、球面収差分布Ａの形状に一致するように低抵抗電極３１と３２の位置と大きさとを決めることが必要である。位相補正素子面での入射光束の半径を１としてこれに対し、低抵抗電極３１の半径を０．２～０．３、円環状の低抵抗電極３２の内半径と外半径との平均半径を０．７～０．８５にしたとき、球面収差を効率よく補正できて好ましい。特に低抵抗電極３１の半径を０．２１にし、低抵抗電極３２の平均半径を０．７４にしたときに、最大の補正効果を得ることができ極めて好ましい。

【００２７】以上、分割電極を等電位にした場合に関して述べたが、この場合、図５のＣに示す残留収差が残る。この残留収差の大きさは補正する球面収差の大きさに比例するため、多層記録ディスクにおける層間ギャップなど、大きな球面収差を補正する場合においては無視することができない。そこで以下に、本発明における位相補正素子による残留収差の低減効果を説明する。

【００２８】図４に示す分割電極は、一様な透明導電膜をエッチングすることにより得られた、同心円状で複数のセグメント電極４１～４７より構成されている。電極を分割する方法には、例えばフォトリソグラフィー技術とエッチング技術を用いることができる。隣接する一つのセグメント電極と他のセグメント電極との間、つまり分割間隔はエッチングにより透明導電膜が除去されているので異なるセグメント電極間では導通はない。しかし、本発明における位相補正素子では、いくつかのセグメント電極が導通するように電極内部で透明導電膜により配線され、これにより信号数を減らしている。

【００２９】すなわち、複数のセグメント電極が２つのセグメント電極群に分けられ、それぞれのセグメント電極群ごとに導電接続されて、対向する透明基板の電極とそれぞれのセグメント電極群との間に異なる電圧が印加

できるように構成されている。このように構成することにより、制御電圧発生手段の数を減らすことができて好ましい。

【００３０】図４に示した例ではセグメント電極４１、４３、４５、４７は一つのセグメント電極群が形成され、図の左右方向に配された配線４９により導通され外部の信号源と接続されており信号５によって任意の電圧が印加できる。同様にセグメント電極４２、４４、４６は他のセグメント電極群が形成され、配線４８により導通され外部の信号源と接続され信号４によって任意の電圧が印加できる。

【００３１】図６は本発明の位相補正素子を用いて球面収差を補正した場合の残留収差を表す波面収差分布である。この図でも瞳半径は入射光束半径により規格化されている。前述したセグメント電極全てを等電位にした場合の残留収差は６１であり、図４に示す信号４、５として異なる電圧を供給した場合の残留収差は６２のようになる。ここで領域Ｄ４１～Ｄ４７はセグメント電極４１、４２～４７に対応している。すなわちＤ４１とはドメイン（Ｄｏｍａｉｎ）４１のことである。

【００３２】セグメント電極の半径を残留収差の形状に応じて適切に設定し、かつセグメント電極間で電位差を発生させることで６１に示した残留収差の凹凸を平滑化でき、残留収差を低減できる。ここでは、セグメント電極４１、４３、４５、４７を等電位とし、セグメント電極４２、４４、４６をこれとは異なる等電位としたが、さらに残留収差を低減させたいときは、信号数を増やしてセグメント電極毎に異なる電圧を印加できるようにすればよい。図４に示す分割電極パターンとは異なるパターンとして例えば、セグメント電極４２だけを他のセグメント電極から絶縁させ、新たな外部の信号源と接続して独立に制御することもでき、信号数は１つ増加するもののさらに残留収差は低減する。

【００３３】次に、本発明における位相補正素子の電極材料に関して述べる。電圧降下型電極の低抵抗電極を形成する電極材料のシート抵抗ρ_Lと高抵抗電極を形成する電極材料のシート抵抗ρ_Hの比$\rho_H／\rho_L$を１０００以上にする。ρ_Hが小さ過ぎるときは、高抵抗電極にも比較的大きな電流が流れ、高抵抗電極と接している低抵抗電極内で電圧降下が生じて、所望の電圧分布を得ることが困難となることがある。一方、ρ_Hが大き過ぎるときは、高抵抗電極の導電性がなくなるため電位分布は発生しない。したがって、以上の条件を満足するためにはρ_Hは10^3 Ω／□～10^7 Ω／□程度がよい。一方、ρ_Lはできるだけ小さくする方が高抵抗電極の許容抵抗範囲が大きくなるため、好ましくは１Ω／□～１００Ω／□程度がよい。

【００３４】低抵抗電極の材料としては、銅、金、アルミニウム、クロムなどの金属材料が導電性・耐久性の点では好ましいが、電極部分で遮光されるため透過率が低下する。したがって、透明導電膜を使用することが好ましい。例えばＩＴＯ膜など比抵抗の小さな透明導電膜を用いることは、上述した低抵抗電極の抵抗値と高抵抗電極の抵抗値との比の条件を満足しかつ透過率も高いため好ましい。また、低抵抗電極に外部の位相補正素子制御回路より、電圧を印加するための電極引出部２７上の配線材料はＩＴＯ膜のような透明導電膜でもよく、クロムやニッケルのような金属膜でもよい。特にニッケルなどハンダで接続できる金属の場合、外部からの信号線を容易にハンダで接続でき好ましい。

【００３５】一方、高抵抗電極の材料としては、透明でありかつ低抵抗電極の材料に比べシート抵抗が高い必要がある。例えばガリウム、アルミニウム、シリコン、イットリウム、インジウムなどの元素を１種または複数種ドープした酸化亜鉛膜や、アンチモン、インジウム、ガリウムなどの元素を１種または複数種ドープした酸化錫膜や、ＩＴＯ膜などがよい。

【００３６】上記の元素がドープされた酸化亜鉛膜や酸化錫膜は、ＩＴＯ膜に比べ容易に高抵抗膜が得られるため好ましい。特に、上記の元素がドープされた酸化亜鉛膜は高比抵抗でありながらエッチング性も良好であり、光の透過率、耐久性に優れている点で本発明の光ヘッド装置における好適な材料である。ＩＴＯ膜を低抵抗電極と高抵抗電極の両方に用いる場合は、比抵抗が異なる膜にする方が膜厚を制御しやすいため好ましい。

【００３７】一方、分割電極の透明導電膜の材料は電圧降下型電極と同様にＩＴＯやガリウム、インジウム、アンチモンなどがドープされた酸化錫や酸化亜鉛など用いることができる。しかしＩＴＯを用いる方が、膜抵抗が低くできる上、透過率が高いため好ましい。

【００３８】また、上記の低抵抗電極は外側、中間、内側の３つの低抵抗電極からなり、光ヘッド装置を構成する対物レンズの瞳半径に対する中間低抵抗電極の内半径と外半径との平均値の比が０．７から０．８５までであり、かつ対物レンズの瞳半径に対する中間低抵抗電極の内半径と外半径との差の比が０．０２から０．１４までである上記の光ヘッド装置とすることによって、光ヘッド装置は適切に球面収差を補正できるために好ましい。

【００３９】

【実施例】本実施例の光ヘッド装置は、光ディスクの厚み変動、対物レンズや光学系の調整誤差などにより生ずる球面収差を補正する位相補正素子を備えている。図１に示す光ヘッド装置に位相補正素子４を組み込み、５つの電気信号源を有する位相補正素子制御回路１０と電気的に接続した。光源である半導体レーザ１からの出射光の波長は４０５ｎｍであり、対物レンズ６のＮＡは０．８５、瞳径は直径３ｍｍである。本例の位相補正素子の素子構造は図２に示したものと同じである。

【００４０】透明基板である厚さ０．５ｍｍの無アルカリガラス基板の表面上にマグネトロンスパッタリング法

により比抵抗５×１０$^{-6}$ Ω・mのＩＴＯ膜を成膜して、フォトリソグラフィーとエッチングの技術によりこのＩＴＯ膜にパターニングを行い、図３に示した電圧降下型電極の低抵抗電極３１～３３と図４に示した分割電極を形成した。そして、低抵抗電極の中心と分割電極の中心とが光軸上にあるよう配された。

【００４１】低抵抗電極３１～３３のシート抵抗値は５０Ω／□、分割電極のシート抵抗値は３００Ω／□であり、分割電極の各セグメント電極間隔は５μｍとした。その後、電圧降下型電極にはガリウムがドープされた酸化亜鉛膜をマグネトロンスパッタリング法により成膜して透明な高抵抗電極３０（比抵抗５×１０$^{-3}$ Ω・m）を形成した。高抵抗電極３０のシート抵抗値が１×１０^{5} Ω／□であり、低抵抗電極３１～３３のシート抵抗値との比は、２０００対１であった。本実施例では図２の電極２４ａを電圧降下型電極とし、電極２４ｂを分割電極とした。

【００４２】その後、電極２４ａ、２４ｂの表面にはシリカを主成分とする絶縁膜２５をスピンコート法により形成した後、ポリイミドを主成分とする配向膜２６を同じくスピンコート法により形成した。このとき、作製した２枚の無アルカリガラス基板を、４μｍのガラス製スペーサが混入されたエポキシ系のシール材を用いて図２に示すセル構造になるよう重ね合わせた。このセルのガラス基板間には常光屈折率と異常光屈折率との差Δｎが０．１５のネマティック液晶を注入し、注入口を封止して液晶セルを形成した。なお、配向膜２６は液晶層２３がホモジニアス配向になるよう事前にラビング処理されている。また、ガラス基板の外側表面に反射防止膜（図示せず）をコートした。

【００４３】低抵抗電極３１は内径０．７mm、外径０．８mm、低抵抗電極３２は内径２．２mm、外径２．５mm、低抵抗電極３３は内径３．２mm、外径４．２mmの光軸を中心とした円環状を有しており、同じ透明導電膜材料で形成された配線により電極引出部部２７から位相補正素子制御回路１０に接続されており、信号１～３を用いて各々の低抵抗電極に任意の電圧を供給できる。ここで、瞳半径（１．５mm）に対する、中間の低抵抗電極３２の内半径と外半径との平均値（１．１７）の比が０．７８であって０．７と０．８５の間にあり、また瞳半径（１．５mm）に対する、中間の低抵抗電極３２の内半径と外半径との差（０．１５）の比が０．１であって０．０２と０．１４の間にあった。

【００４４】一方、図４に示す分割電極は、光軸を中心として内側より直径０．６mm、１．０mm、１．７mm、２．４mm、２．６mm、２．９mmの同心円状のセグメント電極４１～４７に分割されている。セグメント電極４１、４３、４５、４７は同じ透明導電膜材料で形成された配線４９により導通されており、位相補正素子制御回路１０が発生する信号５により等しい電圧が供給された。同様にセグメント電極４２、４４、４６も配線４８により導通され信号４により等しい電圧が供給された。

【００４５】本実施例における位相補正素子は５つの電気信号により制御され、電気信号は周波数１ｋＨｚの矩形交流であり、電圧降下型電極用の信号１、２、３同士、および分割電極用の信号４、５同士はそれぞれ同位相であり、信号１、２、３と信号４、５とは位相がπずれている。したがって、例えば信号１、２、３の電圧をV_1［V_{rms}］、信号４、５をV_2［V_{rms}］とすると、電極間に印加される電圧はV_1+V_2［V_{rms}］となり液晶分子を駆動する。

【００４６】次に本実施例における位相補正素子により球面収差を補正する原理を説明する。図５のＢは対物レンズのＮＡが０．８５、光源の波長が４０５ｎｍの光学系において、光ディスクの厚さが設計値の０．１mmより０．０１mm厚くなった場合に発生する波面収差（球面収差）の半径方向分布を示すグラフである。球面収差は軸対称なので、図５のＢに示した波面収差が瞳半径０つまり光軸を回転対称軸として分布していると考えればよい。

【００４７】０．０１mmの光ディスク厚み変動により発生する球面収差を位相補正素子により補正するために、低抵抗電極３１、３３に１．３V_{rms}、低抵抗電極３２に１．１V_{rms}、セグメント電極４１～４７に電圧０．５V_{rms}を印加した。したがって、液晶層に印加される実効電圧は、低抵抗電極３１、３３で１．８V_{rms}、低抵抗電極３２で１．６V_{rms}となり、高抵抗電極３０の面内においては電圧幅０．２V_{rms}で連続的に変化する電圧分布が生じた。前述の説明と同様に、電圧に応じて液晶分子の配向方向が分布するため、位相補正素子は同心円状の波面変化を発生することができて、その半径方向分布は図４のＢのようになる。

【００４８】ここで球面収差Ａの大きさに応じて信号１～３の電圧を決めているので、球面収差Ａと位相補正素子により発生する球面収差Ｂは相殺する結果、光ディスク面上での波面収差はＣのようになり低減する。補正前の球面収差は約０．１λ_{rms}であったが、位相補正素子を用いて補正した結果、約０．０１８λ_{rms}に減少した。

【００４９】一方、光ディスクの厚さが０．０１mmだけ薄い場合には、図５のＡとは正負が逆転した球面収差を補正するために、低抵抗電極３１、３３に１．１V_{rms}、低抵抗電極３２に１．３V_{rms}を印加すればよい。これにより、位相補正素子によって発生する波面変化も図５のＢの正負を逆転した形になるため、球面収差を相殺できる。

【００５０】次に図５のＣで示される補正後の残留収差を改善するために、電圧降下型電極への印加電圧は変えずに、分割電極を構成するセグメント電極のうちセグメ

ント電極４１、４３、４５、４７に０．４８V_{rms}、セグメント電極４２、４４、４６に０．５２V_{rms}を印加した。これにより分割電極のセグメント電極毎に０．０４V_{rms}の電圧差が生じる結果、液晶層の実質的な屈折率分布も変化する。図６の６２は、この電圧差が生じたときの残留収差を表すグラフで、波面収差として表わしている。セグメント電極４１～４７全てに等しく０．５V_{rms}印加したときの６１に比べ残留収差が低減している様子がわかる。このとき、先に示した補正後の波面収差約０．０１８λ_{rms}は０．００９λ_{rms}まで半減された結果、光ディスクへの情報の記録、再生特性がさらに向上した。

【００５１】以上のように低抵抗電極３１～３３、セグメント電極４１～４７に適切な電圧を印加することにより球面収差を精度良く補正できた。また、低抵抗電極３１、３３は常に等しい電圧を印加しても、光学特性上大きく影響しないために、低抵抗電極３１、３３を導通させて１つの電源に接続させてもよく、この場合４つの外部信号で動作させることができる。

【００５２】

【発明の効果】以上説明したように、本発明の光ヘッド装置においては、液晶層を挟持して位相補正素子を構成する一対の透明基板のそれぞれに形成された電極の一方を、同心円状に配置した３つの円環状の低抵抗電極と少なくとも低抵抗電極間に配された高抵抗電極とで構成し、他方の電極を同心円状に分割された複数のセグメント電極からなる分割電極により構成する位相補正素子を搭載する。

【００５３】この構成を有する位相補正素子は、球面収差形状にほぼ一致した波面変化を発生させることができるため、この位相補正素子を搭載した本発明の光ヘッド装置を用いることにより、光ディスク厚み誤差に起因する球面収差を効率よく補正でき、ノイズの少ない良好な信号光を得ることができる。さらに、従来と比べて少ない外部信号源により動作させることができるため、低いコストの光ヘッド装置を作製できる。

【図面の簡単な説明】

【図１】本発明の光ヘッド装置の原理構成の一例を示す概念図。

【図２】本発明における位相補正素子の構成の一例を示す断面図。

【図３】本発明における位相補正素子の電圧降下型電極パターンの一例を示す平面図。

【図４】本発明における位相補正素子の分割電極パターンの一例を示す平面図。

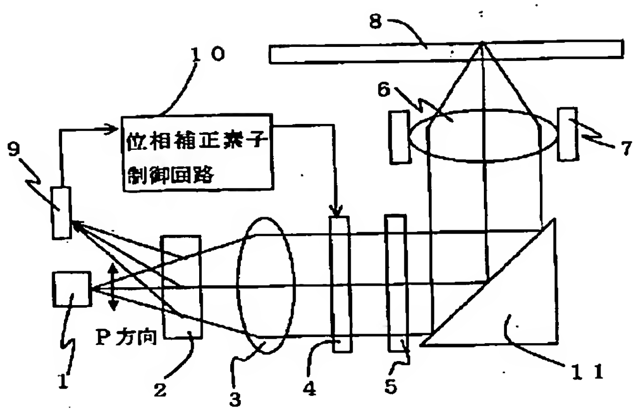
【図５】本発明における分割電極を構成するセグメント電極に同じ電圧を印加した場合における位相補正素子により発生した波面収差による球面収差補正の一例を示すグラフ。（Ａは補正を要する球面収差、Ｂは位相補正素子により発生した波面変化、Ｃは補正後の波面収差、Ｄは低抵抗電極３１に相当する領域、Ｅは低抵抗電極３２に相当する領域）

【図６】本発明における分割電極を構成するセグメント電極に複数の電圧を印加した場合に位相補正素子により発生した波面収差による球面収差補正の一例を示すグラフ。Ｄ４１～Ｄ４７はセグメント電極４１～４７に相当する領域）

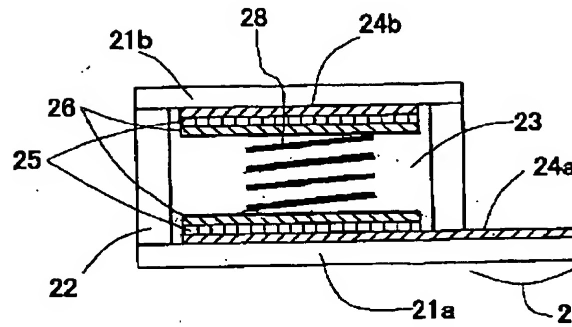
【符号の説明】

１：半導体レーザ
２：偏光ビームスプリッタ
３：コリメートレンズ
４：位相補正素子
５：４分の１波長板
６：対物レンズ
７：アクチュエータ
８：光ディスク
９：光検出器
１０：位相補正素子制御回路
２１ａ、２１ｂ：ガラス基板
２２：シール材
２３：液晶層
２４ａ、２４ｂ：電極
２５：絶縁膜
２６：配向膜
２７：電極引出部
２８：液晶分子
３０：高抵抗電極
３１～３３：低抵抗電極
４１～４７：セグメント電極
４８、４９：配線
６１、６２：残留波面収差

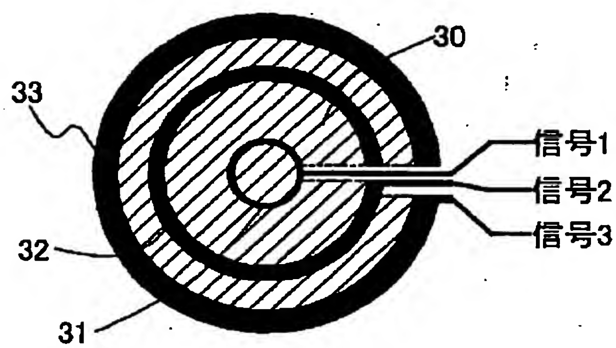
【図１】



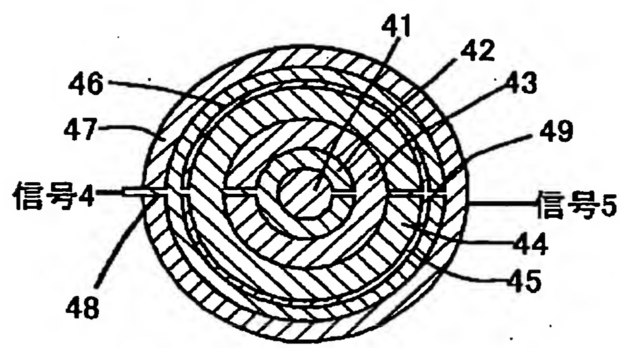
【図２】



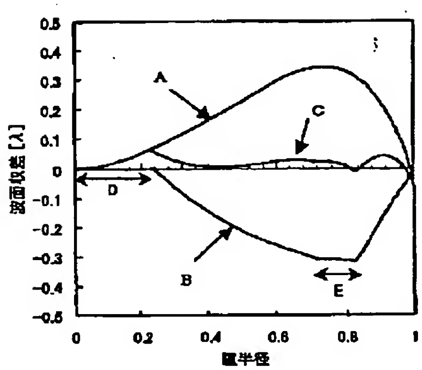
【図３】



【図４】



【図５】



【図６】